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NATIONAL DAM SAFETY PROGRAM. WELSHMANS LAKE DAM (MO 31173), MIS--ETC(U)
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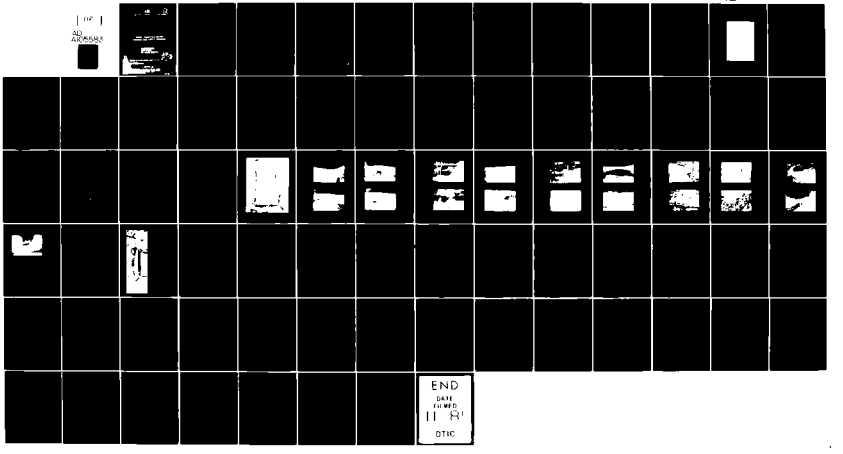

LEVEL II

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19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Dam Safety, Lake, Dam Inspection, Private Dams	
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.	

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☆ U.S. G.P.O. 1980-665-141/1299

WELSHMANS LAKE DAM
ST. FRANCOIS COUNTY, MISSOURI
MISSOURI INVENTORY NO. MO 31173

PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

PREPARED BY
HOSKINS-WESTERN-SONDEREGGER, INC.
CONSULTING ENGINEERS
LINCOLN, NEBRASKA

UNDER DIRECTION OF

ST. LOUIS DISTRICT, CORPS OF ENGINEERS

FOR

GOVERNOR OF MISSOURI

OCTOBER, 1980

DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 TUCKER BOULEVARD, NORTH
ST. LOUIS, MISSOURI 63101

REPLY TO ATTENTION OF

SUBJECT: Welshmans Lake Dam Phase I Inspection Report

This report presents the results of field inspection and evaluation of the Welshmans Lake Dam (MO 31173).

It was prepared under the National Program of Inspection of Non-Federal Dams.

This dam has been classified as unsafe, non-emergency by the St. Louis District as a result of the application of the following criteria:

a. Spillway will not pass 50 percent of the Probable Maximum Flood without overtopping the dam.

b. Overtopping of the dam could result in failure of the dam.

c. Dam failure significantly increases the hazard to loss of life downstream.

SUBMITTED BY: SIGNED
Chief, Engineering Division — 28 APR 1981 — Date

APPROVED BY: SIGNED
Colonel, CE, District Engineer — 30 APR 1981 — Date

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

TABLE OF CONTENTS

APPENDIX A - MAPS

Plate A-1	Vicinity Topography
Plate A-2	Location Map
Plate A-3	Seismic Zone Map

APPENDIX B - PHOTOGRAPHS

Plate B-1		Photo Index
Plate B-2	Photo No. 2	Overview from Right Upstream Bank
	Photo No. 3	Downstream Slope from Right End
Plate B-3	Photo No. 4	Crest of Dam from Right End
	Photo No. 5	Upstream Slope from Right End
Plate B-4	Photo No. 6	View Upstream through Spillway Channel
	Photo No. 7	View of Exit Channel which is normal to end of Spillway Slab
Plate B-5	Photo No. 8	View of Upstream Slope taken from entrance to Spillway Channel
	Photo No. 9	Looking upstream through the Spillway Channel
Plate B-6	Photo No. 10	Crest of Dam looking over the Spillway from the Left End
	Photo No. 11	View shows Woven Wire covering Upstream Slope (for Muskrat Control)
Plate B-7	Photo No. 12	Looking Upstream from near Center of Dam.
	Photo No. 13	Looking Downstream from near Center of Dam.
Plate B-8	Photo No. 14	Seep area near toe of Dam Downstream from Station 3+00
	Photo No. 15	Looking Upstream at Seep Area
Plate B-9	Photo No. 16	Seep Area Downstream from Station 2+50
	Photo No. 17	Thin-bedded Shaley Limestone Outcropping in Left Abutment Trough
Plate B-10	Photo No. 18	View showing undercutting of Downstream Lip of Spillway Apron
	Photo No. 19	Damage Area Downstream of the Dam
Plate B-11	Photo No. 20	Damage Area Downstream of the Dam

APPENDIX C - PROJECT PLATES

Plate C-1	Phase I - Plan and Profile of Dam
Plate C-2	Phase I - Maximum Cross Section of Dam, Spillway Cross Sections and Centerline Profile

APPENDIX D - HYDRAULIC AND HYDROLOGIC COMPUTATIONS

Plates D-1 and D-2	Hydrologic Computations
Plate D-3	Principal Spillway Rating Curve
Plate D-4	Elevation-Area Curve
Plate D-5	Ratio-Discharge Curves
Plates D-6 through D-28	Computer Input and Output for Ratios of PMF

APPENDIX E - GEOLOGY REPORT

Plate E-1 Engineering Geology Report by Missouri Geological Survey

PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM
ASSESSMENT SUMMARY

Name of Dam	Welshmans Lake Dam
State Located	Missouri
County Located	St. Francois County
Stream	Tributary to Cabanne Course
Date of Inspection	October 29, 1980

Welshmans Lake Dam was inspected by an interdisciplinary team of engineers from Hoskins-Western-Sonderegger, Inc. The purpose of the inspection was to make an assessment of the general conditions of the dam with respect to safety, based upon available data and visual inspection, in order to determine if the dam poses hazards to human life or property.

The guidelines used in the assessment were furnished by the Department of the Army, Office of the Chief of Engineers and developed with the help of several Federal and STate agencies, professional engineering organizations, and private engineers.

Welshmans Lake Dam has a height of thirty-two (32) feet and a storage capacity at the minimum top elevation of the dam of one-hundred-two (102) acre-feet. In accordance with the guidelines, a small size dam has a height greater than or equal to twenty-five (25) feet but less than forty (40) feet and a storage capacity greater than or equal to fifty (50) acre-feet but less than one thousand (1,000) acre-feet. The size classification is determined by either the storage capacity or height, whichever gives the larger size category. Welshmans Lake Dam is classified as a small size dam.

In accordance with the guidelines and based on visual observation, the dam is classified as having a high potential for damage and loss of life. Failure would threaten life and property. The estimated damage zone extends approximately two (2) miles downstream of the dam. Within the damage zone are several trailer houses, a barn, and 3 or 4 dwellings.

Our inspection and evaluation indicate that the spillway does not meet the minimum criteria set forth in the recommended guidelines for a small dam having a high hazard potential. In consideration of the small volume of water impounded and the size of hte downstream floodplain 50 percent of the Probable Maximum Flood is the appropriate spillway design flood. The spillway will pass the 100-year flood (a flood having a 1 percent probability of being exceeded in any year) without overtopping the dam. The spillway will pass 35 percent of the Probable Maximum Flood without overtopping the dam. The Probable Maximum Flood (PMF) is defined as the flood that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region.

Welshmans Lake Dam appears to be in excellent structural condition and the maintenance is very good.

Design data were not available for this dam. Based on the field inspection of the dam, the following remedial measure should be implemented by the owner on a high priority basis:

(1) Increase the height of the dam and/or the spillway size to pass 50 percent of the probable maximum flood without overtopping the dam. In either case the spillway should be protected to prevent erosion.

The following operation and maintenance procedures are recommended and should be implemented by the owner in the near future:

(1) Seepage and stability analyses comparable to the requirements of the recommended guidelines should be performed by an engineer experienced in the design and construction of dams.

(2) The seepage at the toe of the dam should be monitored to determine changes in the amount or characteristics of effluent.

(3) Measures should be taken to stabilize or minimize erosion under the concrete apron of the spillway.

(4) Maintenance of this structure is generally very good and should be continued.

(5) A program of regular inspection of the dam and spillway should be initiated, including seepage observations, and records of the inspections should be made a part of this project site.

Rey S. Decker
E-3703

Gordon Jamison

Garold Ulmer
E-19246

H. P. Hoskins

Harold P. Hoskins, Chairman of the Board
Hoskins-Western-Sonderegger, Inc.
E-8696

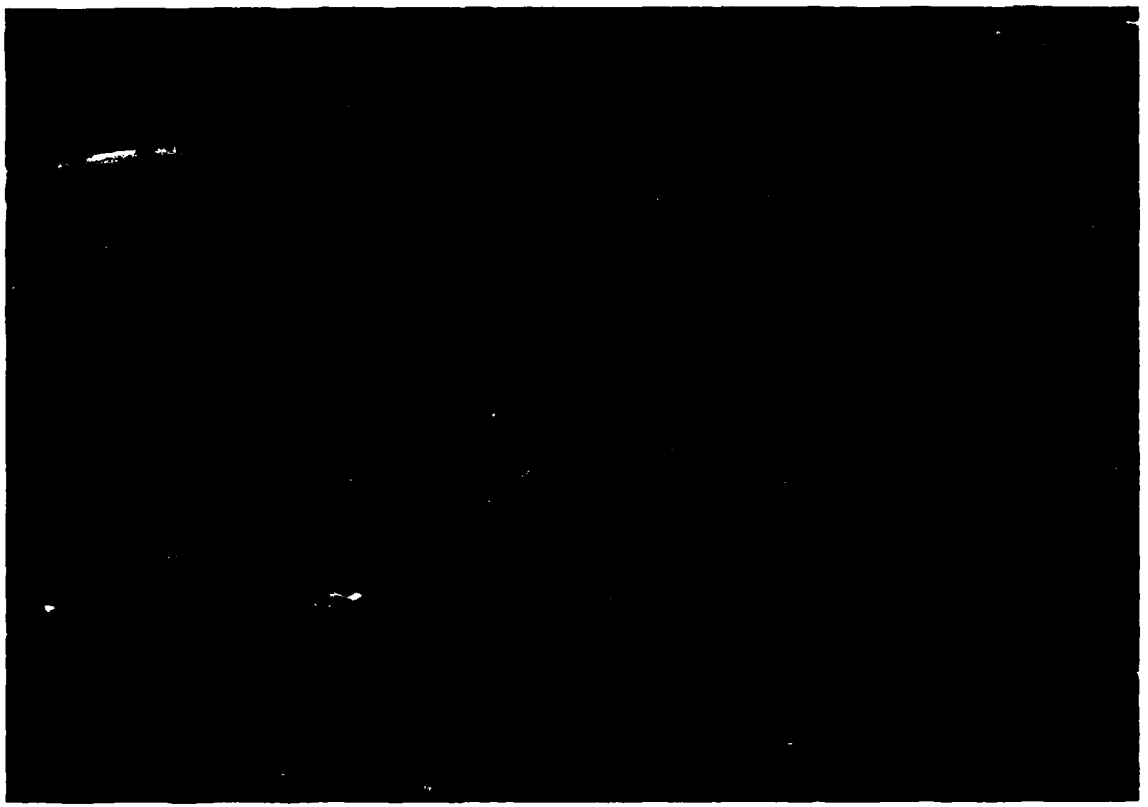


PHOTO NO. 1 - OVERVIEW

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
WELSHMANS LAKE DAM - MO 31173
ST. FRANCOIS COUNTY, MISSOURI

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

a. Authority. The National Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army through the Corps of Engineers, to initiate a program of safety inspection of dams throughout the United States. Pursuant to the above, the St. Louis District, Corps of Engineers, District Engineer directed that a safety inspection of Welshmans Lake Dam be made.

b. Purpose of Inspection. The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and visual inspection, in order to determine if the dam poses hazards to human life or property.

c. Evaluation Criteria. Criteria used to evaluate the dam were furnished by the Department of the Army, Office of the Chief of Engineers, in "Recommended Guidelines for Safety Inspection of Dams", Appendix D to "Report of the Chief of Engineers on the National Program of Inspection of Dams", dated May, 1975, and published by the Department of the Army, Office of the Chief of Engineers.

1.2 DESCRIPTION OF PROJECT

a. Description of Dam and Appurtenances.

(1) Embankment. This dam is a small earth fill structure approximately 440 feet in length and 32 feet in height. The maximum water storage at the minimum top of dam elevation is 102 acre-feet.

(2) Principal Spillway. The uncontrolled principal (and only) spillway is excavated through the left abutment. Approximately 37 feet of the channel is paved with a trapezoidal shaped concrete slab that culminates at the edge of the downstream exit channel with a 30 foot ± length concrete sill. Flows over the sill enter the downstream channel approximately normal to the centerline of the exit channel. The exit channel is cut into shale and siltstone.

(3) Low-Level Outlet. There is no operating low-level outlet. A six-inch pipe was installed at the time of construction but has since been plugged with concrete and is no longer operative.

(4) Pertinent physical data are given in paragraph 1.3.

b. Location. The dam is located in the northwest part of St. Francois County as shown on Plate A-2. The dam is about one mile southwest of the City of Bonne Terre and is shown on Plate A-1 in the SW 1/4 of Section 15, T37N, R4E. The lake formed behind the dam is in the same quarter section.

c. Size Classification. Criteria for determining the size classification of dams and impoundments are presented in the guidelines referenced in paragraph 1.1c above. Welshmans Lake Dam has a height of 32 feet and a storage capacity of 102 acre-feet. This dam is classified as a small size dam. A small size dam has a height greater than or equal to 25 feet but less than 40 feet and a storage capacity greater than or equal to 50 acre-feet but less than 1,000 acre-feet. The size classification is determined by either the storage or height, whichever gives the larger size category.

d. Hazard Classification. Guidelines for determining hazard classification of dams and impoundments are presented in the guidelines as referenced in paragraph 1.1c above.

Aerial photographs of the downstream damage zone of this dam were taken in October, 1980. These photographs were used as reference in the field observations of the damage zone which were made during the inspection. Based on the field observations and on the referenced guidelines this dam is in the High Hazard Potential Classification. The estimated damage zone extends approximately two miles downstream of the dam. Within the damage zone are several trailer houses, a barn, and 3-4 dwellings. Photos 19 and 20 show some of the damage area.

e. Ownership. The dam is owned by Mr. Paul Williams, President, U.S. Tool Grinding, Inc., 34 Birch Street, Desloge, Missouri 63601.

f. Purpose of Dam. Recreation.

g. Design and Construction History. No plans were found for the dam. Mr. Williams said the dam was built in 1973 and that the Missouri State Conservation Department helped in the development. A geologic report prepared by the Missouri Geological Survey is included with this report in Appendix E. Mr. Williams reported that a core trench was excavated to a depth of about 10 feet and was bottomed in shale. Most of the material for the embankment came from the top of the hill on the left abutment.

h. Normal Operating Procedure. There are no operating facilities for this dam. The pool level is controlled by rainfall, infiltration, evaporation, and the capacity of the uncontrolled spillway. Mr. Williams reported that the maximum flow through the spillway was 1 to 1.5 feet. The dam has never been overtopped.

1.3 PERTINENT DATA

a. Drainage Area. 143.9 acres (0.225 square miles).

b. Discharge at Damsite.

(1) All discharges at the damsite are through the uncontrolled principal spillway excavated through the left abutment.

(2) Estimated maximum flood at damsite -- Mr. Williams reported that the maximum depth of flow through the spillway was approximately 18 inches.

(3) The principal spillway capacity varies from 0 c.f.s. at elevation 819.4 feet to 467 c.f.s. at the minimum top of dam (elevation 823.9 feet).

(4) Total spillway capacity at the minimum top of dam is 467 c.f.s.±.

c. Elevations (feet above M.S.L.).

(1) Observed pool - 816

(2) Normal pool - 819.4

(3) Spillway crest - 819.4

(4) Maximum experienced pool - 821±

(5) Top of dam (minimum) - 823.9

(6) Streambed - 792 ±

(7) Maximum Tailwater - Unknown

d. Reservoir. Length (feet) of pool.

(1) At spillway crest - 1100

(2) At top of dam (minimum) - 1400

e. Storage (Acre-feet).

(1) Observed pool - 45±

(2) Normal pool - 65±

(3) Spillway crest - 65±

(4) Maximum experienced pool - 80±

(5) Top of dam (minimum) - 102

f. Reservoir Surface (Acres).

(1) Observed pool - 5.5 ±

(2) Normal pool - 7.1 ±

(3) Spillway crest - 7.1 ±

(4) Maximum experienced pool - 7.8 ±

(5) Top of dam (minimum) - 9.1 ±

g. Dam.

(1) Type - Earth fill

(2) Length - 440 ft

(3) Height - 32 ft

(4) Top Width - 16 ft average (varies from 15 to 18 feet)

(5) Side slopes.

(a) Downstream - 1V on 2.4H ±

(b) Upstream - 1V on 2.8H ± (to water edge)

(6) Zoning - None

(7) Impervious core - Unknown

(8) Cutoff - 10 feet deep into shale (reported by owner)

(9) Grout curtain - None

(10) Wave protection - Vegetation

(11) Drains - None

h. Diversion Channel and Regulating Tunnel. - None

i. Spillway.

(1) Principal (and only)

(a) Type - Uncontrolled channel excavated through the left abutment.

(b) Control section - Concrete slab sill approximately 30 ft long

(c) Crest elevation - 819.4 ft

(d) Upstream channel - To shale and limestone bedrock, approximately flat slope and 100 ft in length

(e) Downstream channel - Cut into shale running normal to concrete sill section. 8.7 ± % grade

j. Regulating Outlets. - None

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

No design data were available for this dam. The Missouri Geological Survey made an investigation of the site in 1969. A copy of this report is included in Appendix E.

2.2 CONSTRUCTION

No construction records were available. Mr. Williams reported that the dam was built in 1973 and that the core trench was about 10 feet deep and was blasted into shale.

2.3 OPERATION

There are no operating procedures for this dam.

2.4 EVALUATION

a. Availability. No design data were available.

b. Adequacy. The field surveys and visual observations presented herein are considered adequate to support the conclusions of this report. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record.

c. Validity. Not applicable.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

a. General. A visual inspection of the Welshmans Lake Dam was made on October 29, 1980. Engineers from Hoskins-Western-Sonderegger, Inc., Lincoln, Nebraska, making the inspection were:

Rey S. Decker - Geotechnical
Garold G. Ulmer - Hydraulics and Hydrology
Gordon Jamison - Hydraulics and Hydrology

The owner, Mr. Paul Williams, and the caretaker, Mr. Richard Hickman, were present during the inspection.

b. Dam.

(1) Geology and Soils (abutment and embankment). This dam is situated in the Ozark Physiographic Province. Its upland setting is topographically characteristic of the province exhibiting moderate slopes, youthful valleys, a thin to absent loess mantle and exposures of the Upper Cambrian bedrock formations. The structural setting is typical of the Ozark Uplift. Multiple faults comprising the Big River, Simons Mountain and Cabanne Systems surround the area. Seismic activity is moderate; however, the recorded intensities are low.

The bedrock formation is the Derby-Doerun formation of the Elvins Group of the Upper Cambrian and consists of alternating beds of thinly-bedded arkosic limestones, shales and medium-bedded dolomites. Solution cavitation and fracture porosity is not evident in the bedrock exposures. Thin-bedded silty shales and limestones are exposed in the left abutment trough and in the exit channel of the spillway. Seepage at the shale-limestone contact at the left abutment base and in the shales in the valley bottom exhibited flows of less than 0.5 gpm at the dam site and less than 5 gpm in the channel downstream of the dam. Materials in the narrow valley section consist of 5 to 10 feet of CL-ML alluvium-colluvium overlying shale. Materials in the embankment consist of CL-CH soils borrowed principally from a gently sloping glade area above the left abutment. Numerous earthquakes ranging in Modified Mercalli intensity from II to V are recorded by Stover, Reagor and Algermission, 1979. These include dates in 1884, 1907, 1929, 1946, 1966, 1969, 1970 and 1973. All occurred at a radial distance of less than 30 miles from the dam site. The entire watershed is owned by Mr. Williams and is maintained as a primitive area.

(2) Upstream Slope. The upstream slope is covered with a good vegetative cover of fescue and crown vetch. It has a woven

wire cover for muskrat control that extends from normal pool level about 5 feet up the slope. Photo No. 11 shows the woven wire. There is some slight erosion at the normal pool elevation. No cracks, slumps, or other deformations were observed. No rodent activity was observed. Photos 5 and 11 show the upstream slope.

(3) Crest. Field measurements indicate the crest elevation varies approximately 18 inches. The crest width varies from 15 feet to 18 feet. The crest has a good vegetative cover. There was no evidence of cracks or deformations. Photos No. 3, 4, and 10 show the crest.

(4) Downstream Slope. The downstream slope has an excellent cover of fescue and crown vetch. The downstream slope is approximately 1V to 2.4H, with no evidence of cracks, slides, or rodent activity. Photo 3 shows the downstream slope. There are signs of seepage near the toe of the slope downstream from about Sta. 3+00. Borings about 25 feet up the slope from the seepage outcrop indicate water at about 2' (could be the phreatic surface). Materials in the borings were CL or CH and erosion resistant. Seepage from this area was discharging at less than 0.5 gal/min. Photos 14 and 15 show this seep area. Mr. Williams reported that a 6-inch diameter drawdown pipe with valve was installed through the base of the dam. Some leakage developed along this pipe, and it had been plugged by pumping it full of concrete. (This recent work accounts for the disturbed surface shown in the photos).

Another seep area was observed at the toe of the slope downstream from Sta. 2+50 in the left abutment trough. This area was dry at the time of inspection but supported a good growth of cattails. It would appear that this seepage comes through the thinly bedded siltstone and shaley limestone in the left abutment. Photo No. 16 shows the seep area, and Photo No. 17 shows the shaley limestone outcrop at the toe of the left abutment trough, just up the slope from the seep area.

c. Appurtenant Structures.

(1) Principal Spillway. The spillway channel is excavated in the left abutment. The floor of the entrance channel is shaley limestone and is capped with a control of concrete about 30 ft long. The inside banks of the inlet channel are covered with indurated sandstone riprap. The exit channel is normal to the downstream apron and is cut into shale and limestone. Photos No. 6, 7, 9, 10 and 18 show views of the spillway.

The outflow apron of the concrete sill is undercutting. It appears that the apron has been extended to correct this problem, but erosion is still active under the apron. Photo No. 18 shows the undercutting of the apron.

(2) Low-Level Outlet. The 6-inch diameter pipe which was installed at the time of construction has been plugged with concrete and is no longer operative.

d. Reservoir Area. There is no significant erosion around the shoreline. The shoreline appears to be clear of trees, brush, and trash. The reservoir elevation was 816 ft (3.4 ft below the crest of the spillway) at the time of inspection. There was no evidence of abnormal siltation in the reservoir. Photos No. 2 and 12 show portions of the reservoir.

e. Downstream Channel. The downstream channel is cut to bedrock and is overgrown with a natural growth of trees and brush.

3.2 EVALUATION

Based on visual inspection and measurements, the dam appears to be in excellent structural condition with no likely potential of failure. Materials in the dam appear to be highly resistant to erosion and piping, and the present seepage at the toe of the dam should not endanger the stability of the structure. Erosion in the spillway channel does not endanger the dam nor should it lead to any sudden breach of the reservoir.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

There are no controlled outlet works for this dam. The pool level is controlled by rainfall, infiltration, evaporation, and the capacity of the uncontrolled spillways.

4.2 MAINTENANCE OF DAM

Maintenance of the dam appears to be excellent. The crown vetch cover minimizes maintenance. The caretaker, Mr. Hickman, lives near the right end of the dam and is available for on-the-spot repairs. Some additional measures should be taken to stabilize the downstream apron of the spillway sill. Mr. Hickman traps out the muskrats and/or beavers as they occur.

4.3 MAINTENANCE OF OPERATING FACILITIES

No operating facilities exist at this dam.

4.4 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT

There is no warning system in effect for this dam.

4.5 EVALUATION

The excellent condition of this dam is in great part due to the pride of the owner and the availability and resourcefulness of the caretaker.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

a. Design Data. No design data were found for this dam.

b. Experience Data. The drainage area, reservoir surface area, and elevation-storage data were developed from the USGS Bonne Terre, Missouri 7-1/2 minute topographic quadrangle map. The hydraulic computations for the spillway and dam overtopping discharge ratings were based on data collected in the field at the time of the field inspection. Hydrologic computations are included in this report as Appendix D.

c. Visual Observations.

(1) The principal spillway is in good condition with minor undercutting of the downstream apron.

(2) The crest as well as both slopes are in excellent condition.

d. Overtopping Potential. The spillway is too small to pass 50 percent of the probable maximum flood without overtopping. The spillway will pass 35% of the probable maximum flood and the 1% probability flood without overtopping. Overtopping of a dam should always be avoided. Overtopping would be dangerous because the flow of the water over the crest could erode the downstream face of the dam and, if continued long enough, could breach the dam with sudden release of all of the impounded water onto the downstream flood plain.

The results of the routings through the dam are tabulated in regards to the following conditions:

Frequency	Inflow Discharge c.f.s.	Outflow Discharge c.f.s.	Maximum Pool Elevation	*Maximum Depth Over Dam Feet	Duration Over Top Hours
1%	650	220	822.3	-	-
1/2 PMF	1360	835	824.9	1.0	1-
PMF	2720	2540	826.1	2.2	3+
0.35 PMF	960	470	823.9	-	-

* Minimum top of dam elevation - 823.9

According to the recommended guidelines from the Department of the Army, Office of the Chief of Engineers, this dam is classified as having a high hazard potential rating and a small size. Therefore, the 1/2 PMF to PMF is the test for the adequacy of the dam and its spillway.

The estimated damage zone is described in paragraph 1.2d in this report.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observation. Based on visual observation and measurements this dam appears to be in excellent condition and structurally stable. There was no evidence of slumps, cracks, slides or abnormal deformations that would indicate structural stress. The nature of the materials in the embankment and the downstream slope of 1V on 2.4H should provide adequate safety against shear failures. The effects of seepage on the stability of the dam are unknown although no detrimental effects were observed during the inspection.

b. Design and Construction Data. No design or construction data were available. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

c. Operating Records. There are no controlled operating facilities for this dam.

d. Post Construction Changes. Mr. Williams reported that the 6-inch drawdown pipe was pumped full of concrete to correct some seepage or leakage problems that developed after the dam was completed.

e. Seismic Stability. This dam is located in Seismic Zone 2 as shown on Plate A-3. An earthquake of the magnitude predicted in this area could cause minor structural damage to this dam.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT

a. Safety. Based on visual observations and the measurements made during the inspection, this dam appears to be in excellent condition and structurally stable. The approximate hydrologic analysis performed for this report indicates that the spillway is too small to pass 50 percent of the probable maximum flood without overtopping the dam. The spillway will pass the 1 percent probability flood as well as 35 percent of the probable maximum flood without overtopping. The 50 percent probable maximum flood will overtop the lowest point on the crest of the dam by one foot for a period of one hour. The erosional damage to the dam caused by such overtopping is not known.

The erosion and undercutting under the concrete spillway apron is not serious at the present time but could lead to deterioration of the concrete control section if not corrected.

Seepage along the toe of the dam does not appear, at the present time, to endanger the stability of the dam. It would be well, however, to monitor the seep areas for changes in volume and characteristics. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

b. Adequacy of Information. The measurements and observations made during the inspection are considered adequate to support the conclusions set forth in this report. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

c. Urgency. The remedial measures recommended in paragraph 7.2b should be accomplished in the near future. The item recommended in paragraph 7.2a. should be pursued on a high priority basis.

d. Necessity for Further Investigations. The seepage and stability analyses recommended in paragraph 7.2b should be accomplished by the owner in the near future.

e. Seismic Stability. This dam is located in Seismic Zone 2 as shown on Plate A-3. An earthquake of this magnitude is expected to cause some minor damage to this dam. It is recommended that the prescribed seismic loading for Seismic Zone 2 be applied in any stability analyses performed for this dam.

7.2 REMEDIAL MEASURES

The following remedial measures and maintenance procedures are recommended. All remedial measures should be performed under the guidance of a registered professional engineer experienced in the design and construction of earth dams.

a. Alternatives.

(1) Increase the height of the dam and/or the spillway size to pass 50 percent of the probable maximum flood without overtopping the dam. In either case the spillway should be protected to prevent erosion.

b. Operation and Maintenance Procedures.

(1) Seepage and stability analyses comparable to the requirements of the recommended guidelines should be performed by an engineer experienced in the design and construction of dams.

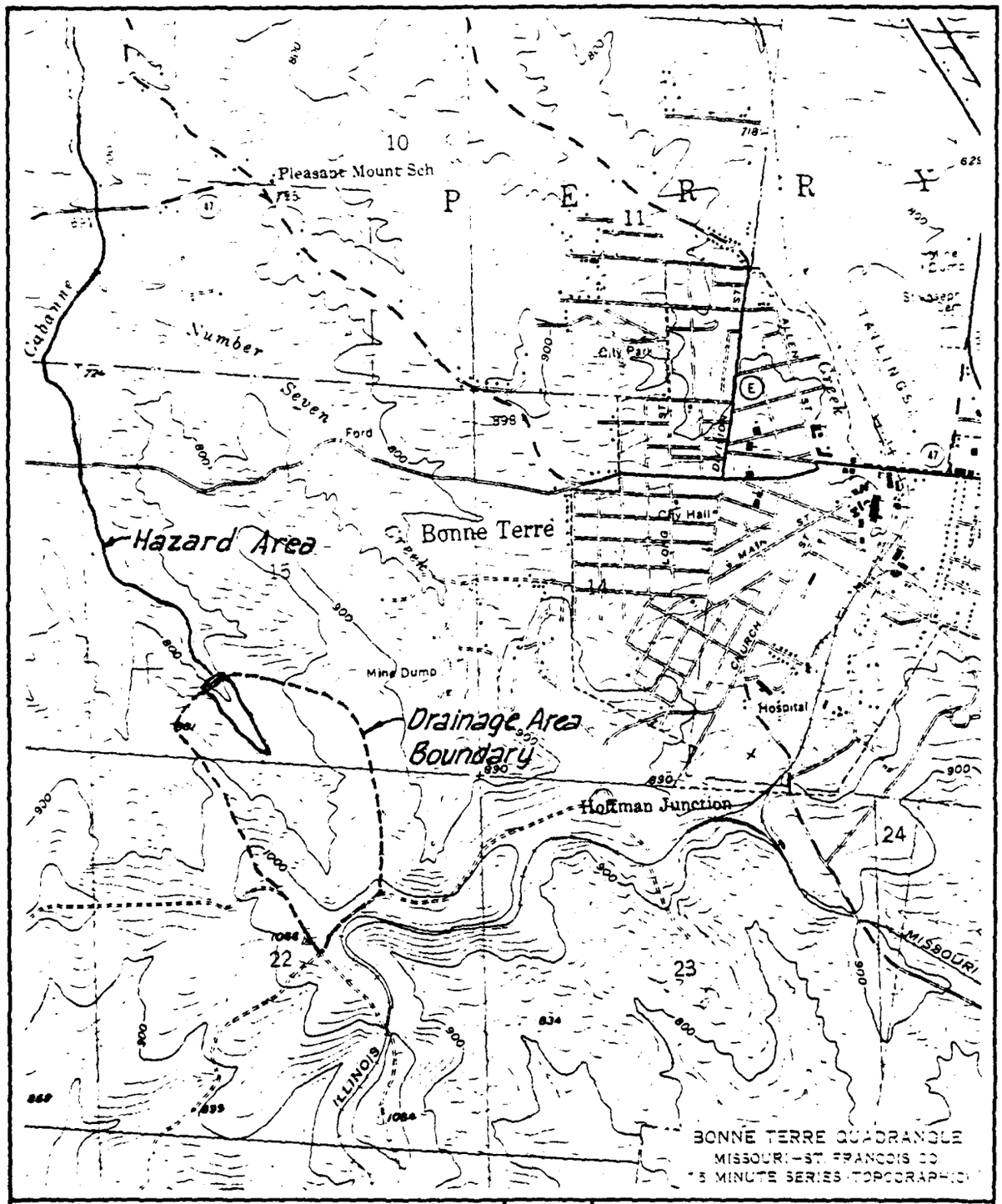
(2) The seepage at the toe of the dam should be monitored to determine changes in the amount or characteristics of effluent.

(3) Measures should be taken to stabilize or minimize erosion under the concrete apron of the spillway.

(4) Maintenance of this structure is generally very good and should be continued.

(5) A program of regular inspection of the dam and spillway should be initiated, including seepage observations, and records of the inspections should be made a part of this project file.

APPENDIX A
MAPS



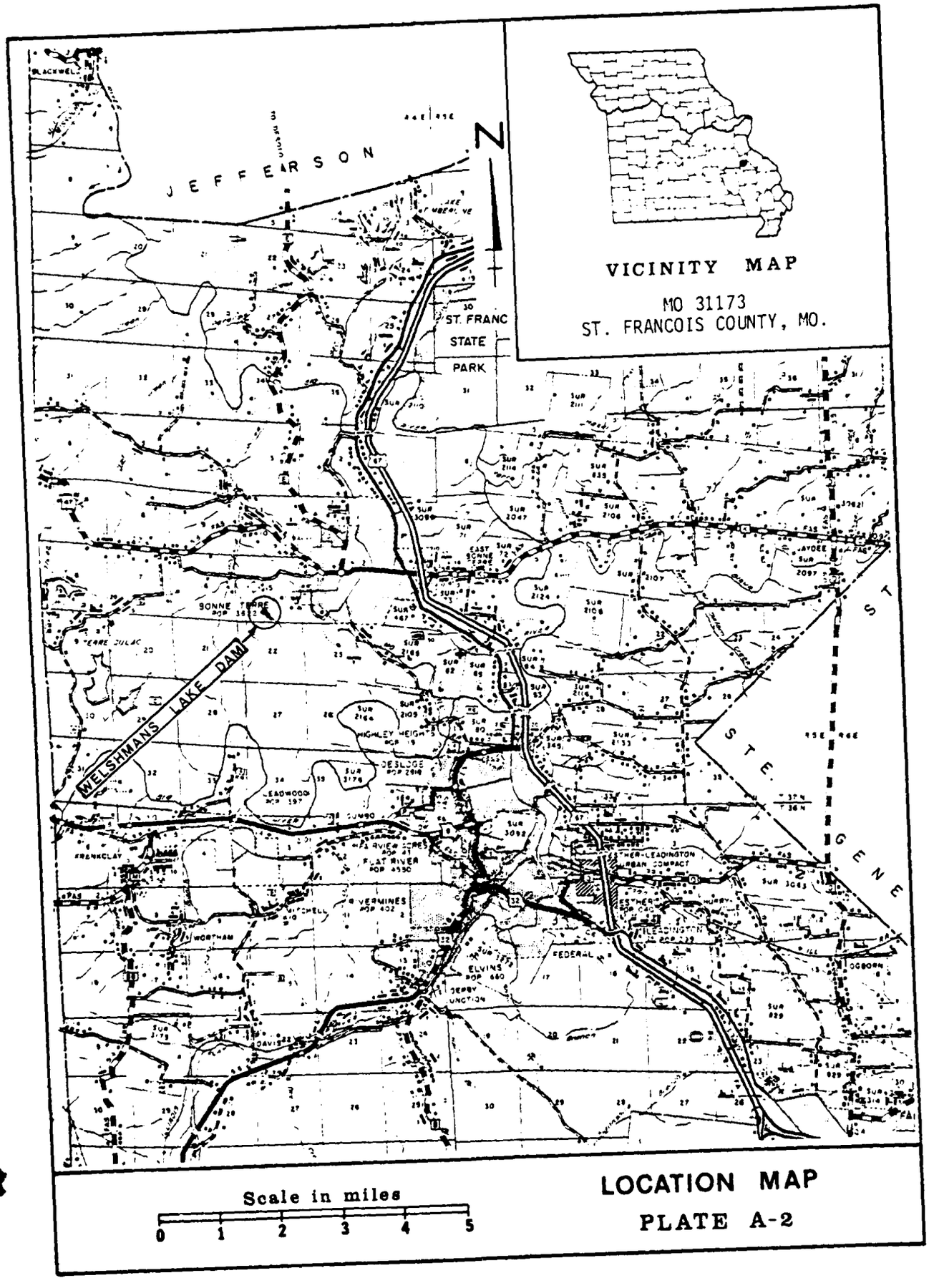
VICINITY TOPOGRAPHY

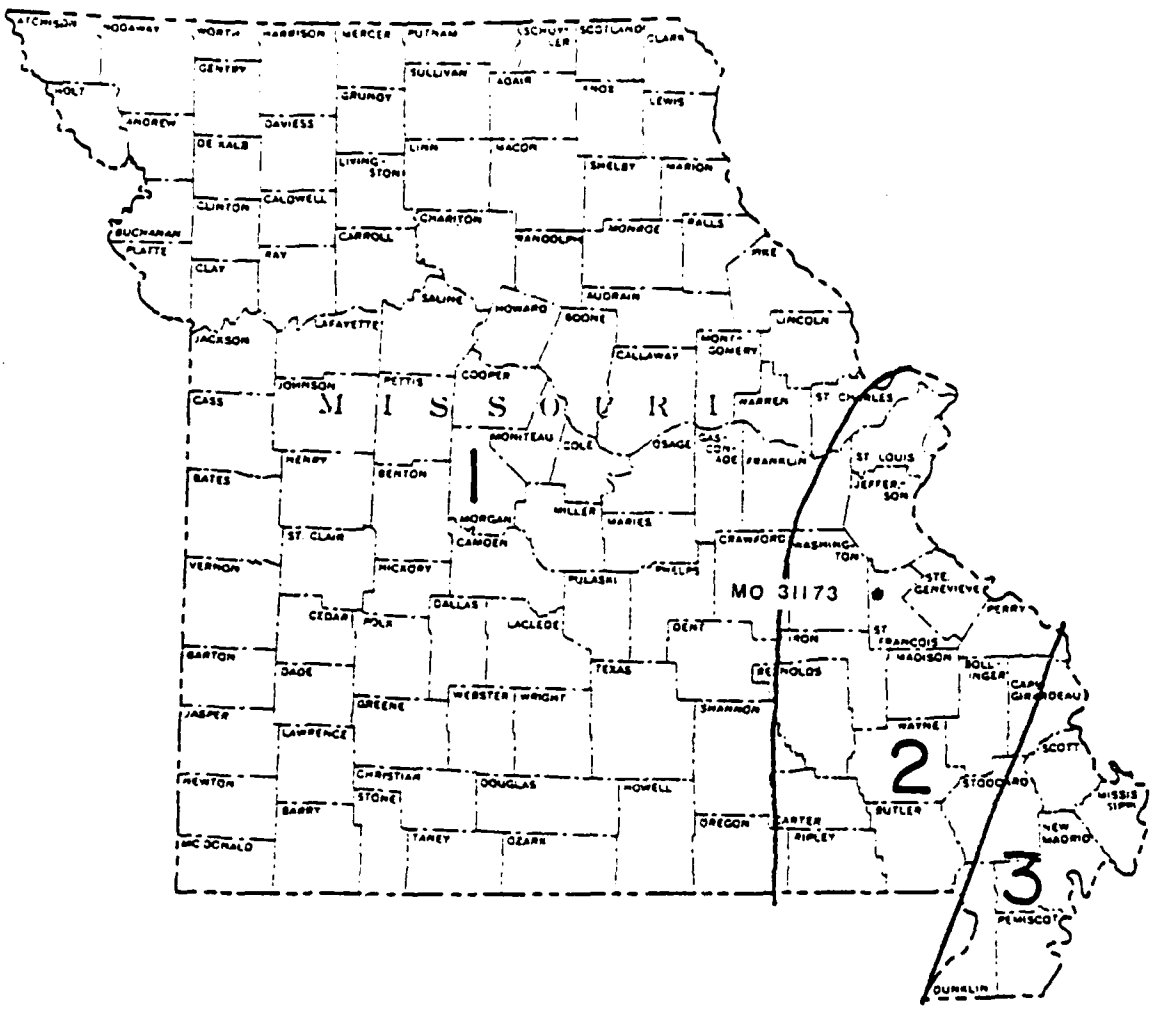
WELSHMANS LAKE DAM

ST. FRANCOIS COUNTY, MISSOURI

MO 31173

PLATE A-1

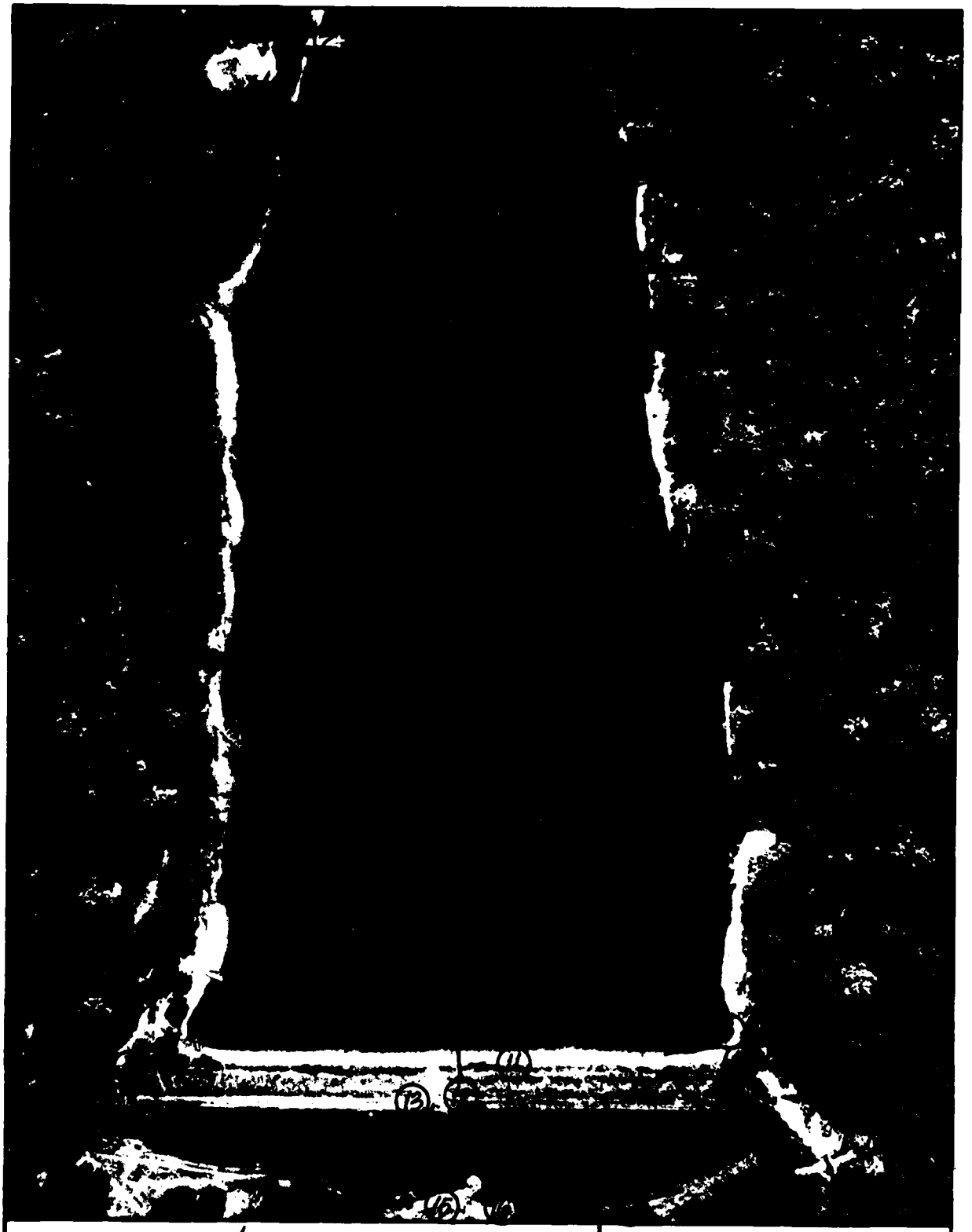

JEFFERSON
N
ST. FRANC
STATE
PARK
WELSHMANS LAKE DAM
SONNE TERRE
HIGHLEY HEIGHTS
DESLOGE
LEADWOOD
FLAT RIVER
VERMINES
WORTHAM
ELVINS
JERRY JUNCTION
FEDERAL
DAVIS
OGBORN
FRANKCLAY
VICINITY MAP
MO 31173
ST. FRANCOIS COUNTY, MO.
Scale in miles
0 1 2 3 4 5
LOCATION MAP
PLATE A-2



MISSOURI
SEISMIC ZONE MAP

PLATE A-3

APPENDIX B
PHOTOGRAPHS



WELSHMAN'S LAKE DAM
ST. FRANCOIS COUNTY, MISSOURI
MO. 31173

PHOTO INDEX

PLATE B-1

PHOTO NO. 2 - OVERVIEW FROM RIGHT UPSTREAM BANK

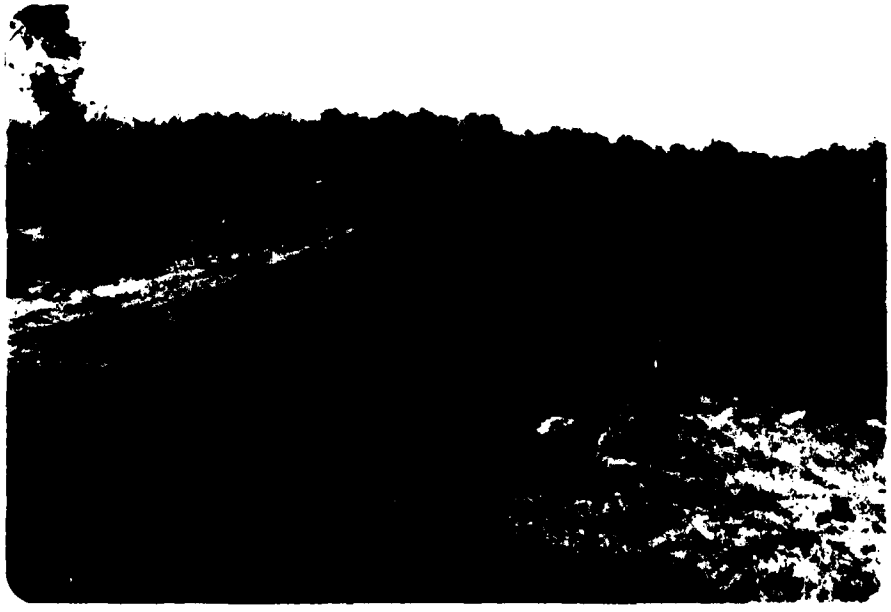


PHOTO NO. 3 - DOWNSTREAM SLOPE FROM RIGHT END

PHOTO 4 - CREST OF DAM FROM RIGHT END

PHOTO 5 - UPSTREAM SLOPE FROM RIGHT END

PHOTO NO. 6 - VIEW LOOKING UPSTREAM THROUGH THE SPILLWAY CHANNEL

PHOTO NO. 7 - VIEW OF EXIT CHANNEL WHICH IS NORMAL TO END OF SPILLWAY SLAB

PHOTO 8 - VIEW OF UPSTREAM SLOPE TAKEN FROM ENTRANCE TO SPILLWAY CHANNEL

PHOTO 9 - LOOKING DOWNSTREAM THROUGH THE SPILLWAY CHANNEL

PHOTO NO. 10 - CREST OF DAM LOOKING OVER THE SPILLWAY FROM THE LEFT END

PHOTO NO. 11 - VIEW SHOWS THE WOVEN WIRE COVERING THE UPSTREAM SLOPE (FOR MUSKRAT CONTROL)

PHOTO NO. 12 - LOOKING UPSTREAM FROM NEAR CENTER OF DAM

PHOTO NO. 13 - LOOKING DOWNSTREAM FROM NEAR CENTER OF DAM

PHOTO NO. 14 - SEEP AREA NEAR TOE OF DAM DOWNSTREAM FROM STATION 3+00

PHOTO NO. 15 - LOOKING UPSTREAM AT SEEP AREA

PHOTO NO. 16 - SEEP AREA DOWNSTREAM FROM STATION 2+50

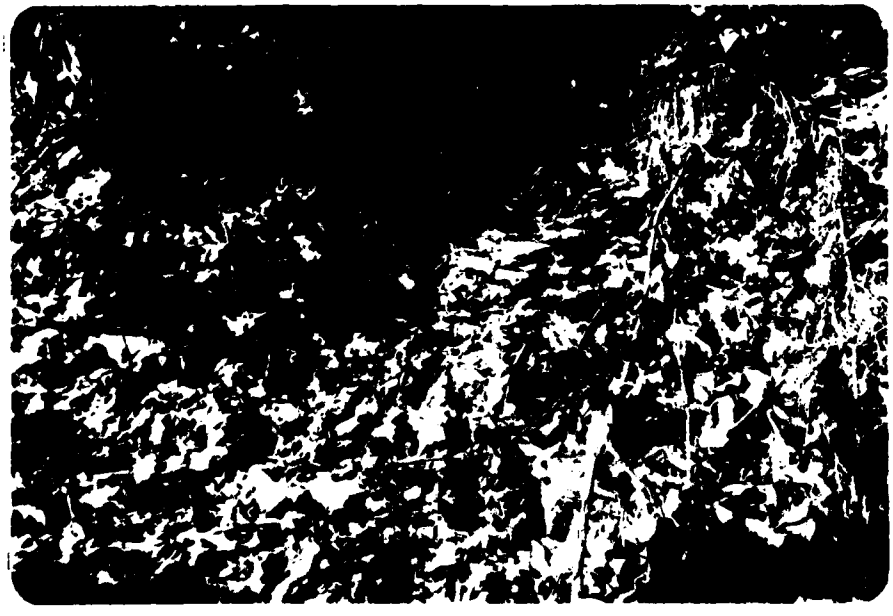


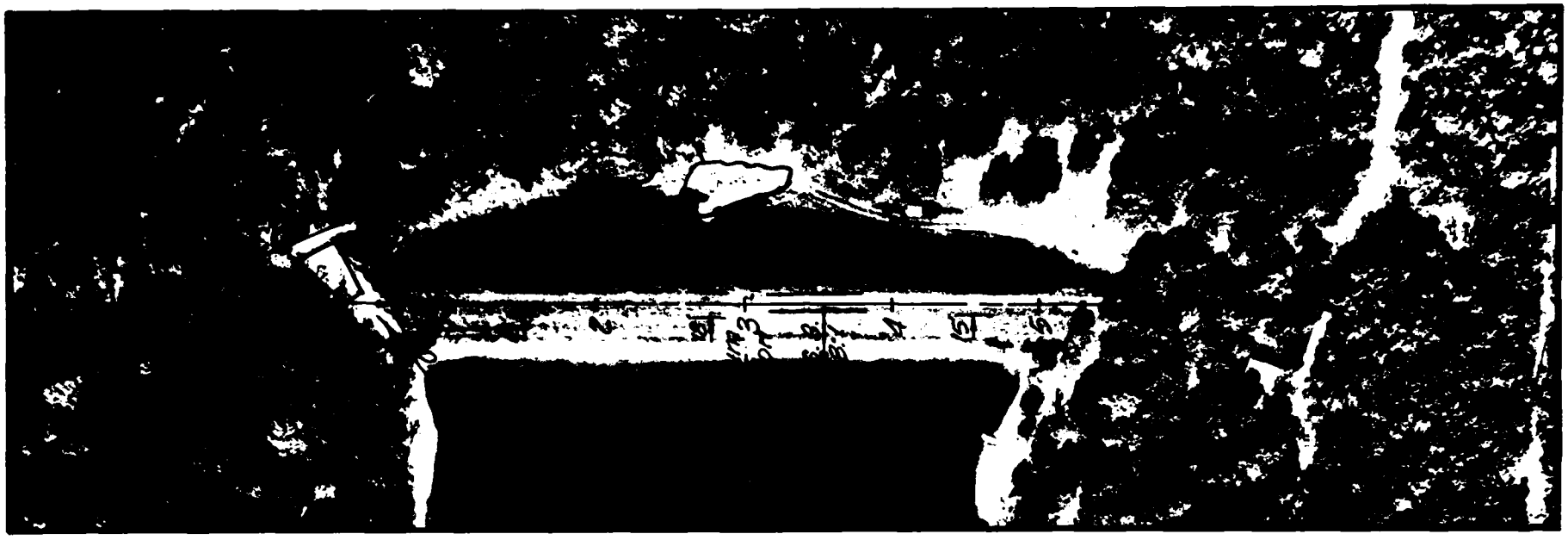
PHOTO NO. 17 - THIN BEDDED SHALEY LIMESTONE OUTCROPPING IN THE TOE OF THE LEFT ABUTMENT TROUGH

PHOTO NO. 18 - VIEW SHOWING UNDERCUTTING OF THE DOWNSTREAM LIP OF THE SPILLWAY APRON

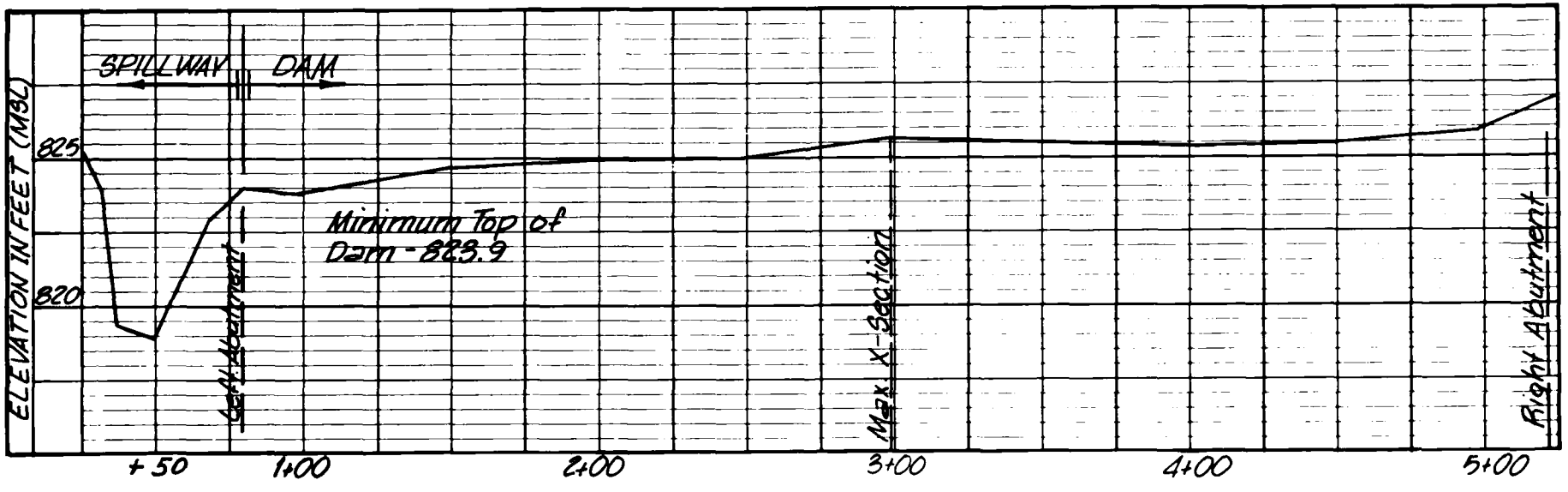
PHOTO NO. 19 - DAMAGE AREA DOWNSTREAM FROM DAM

PHOTO NO. 20 - DAMAGE AREA DOWNSTREAM FROM DAM

APPENDIX C
PROJECT PLATES



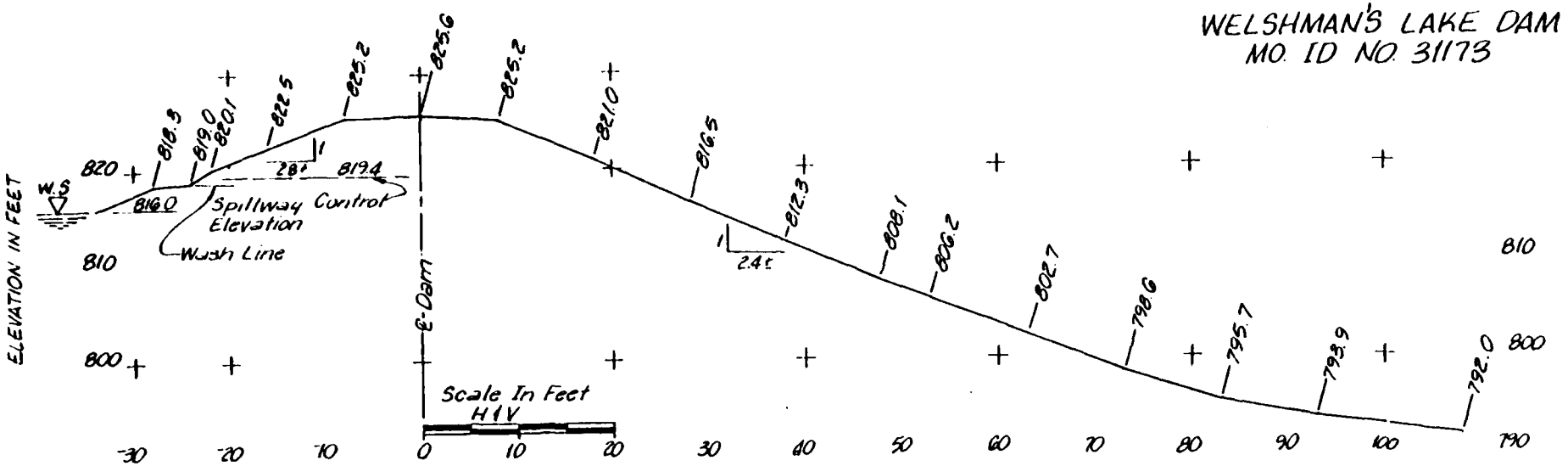
PLAN OF DAM
Scale: 1"= 100'



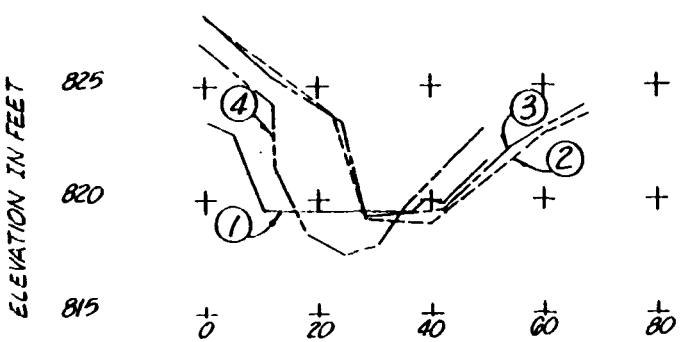
CENTERLINE PROFILE OF DAM
Scale As Shown

PLATE C-1

WELSHMAN'S LAKE DAM
MO. ID NO. 31173



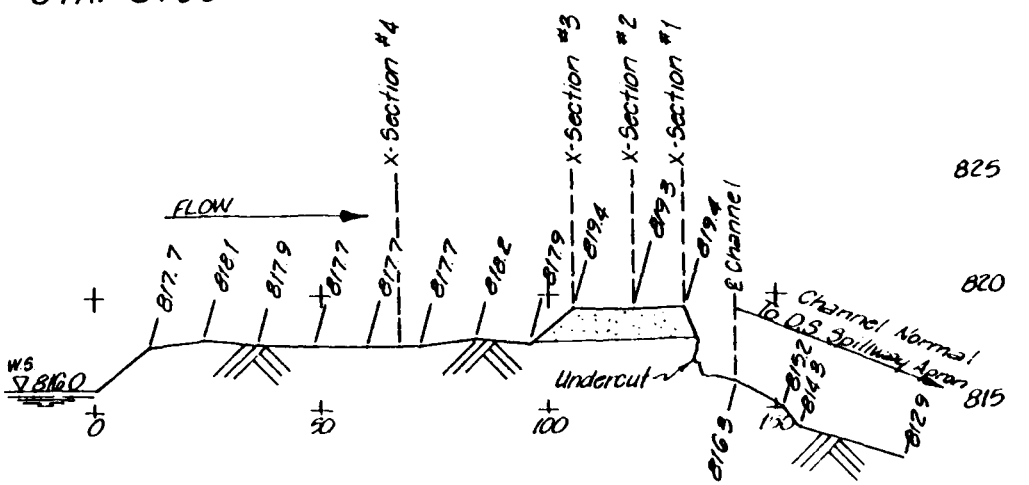
MAXIMUM CROSS-SECTION OF DAM AT STA. 3+00



SPILLWAY CROSS-SECTIONS

Scale: Horiz. 0 20 40

Scale: Vert. 0 5 10



PROFILE ALONG CENTERLINE OF PRINCIPAL SPILLWA

0 25 50

Scale: Horiz.

0 5 10

Scale: Vert

PLATE C-2

APPENDIX D
HYDRAULIC AND HYDROLOGIC DATA

HYDROLOGIC COMPUTATION

1. The SCS dimensionless unit hydrograph and the systemized computer program HEC-1 (Dam Safety Version), July 1978, prepared by the Hydrologic Engineering Center, U.S. Corps of Engineers, Davis, California, were used to develop the inflow hydrographs (See this Section).

   a. Twenty-four hour, one percent probabilistic rainfall for the dam location was taken from the data for the rainfall station at Sullivan, MO. as supplied by the St. Louis District, Corps of Engineers per their letter dated 6 March 1979. The twenty-four hour probable maximum precipitation was taken from the curves of Hydrometeorological Report No. 33 and current Corps of Engineers and St. Louis policy and guidance for hydraulics and hydrology.

   b. Drainage area = 0.225 square miles (143.9 acres).

   c. Time of concentration of runoff = 14 minutes (computed from the "Kirpich" formula and the California Department of Highways Culvert Practice formula).

   d. The antecedent storm conditions for the probable maximum precipitation were heavy rainfall and low temperatures which occurred on the previous 5 days (SCS AMC III). The antecedent storm conditions for the one percent probabilistic precipitation were an average of the conditions which have preceded the occurrence of the maximum annual flood on numerous watersheds (SCS AMC II). The initial pool elevation was assumed at the crest of the principal spillway.

   e. The total twenty-four hour storm duration losses for the one percent probabilistic storm were 2.66 inches. The total losses for the PMF storm were 1.44 inches. These data are based on SCS runoff curve No. 77 and No. 89 for antecedent moisture conditions SCS AMC II and AMC III respectively. The watershed is composed primarily of SCS soil groups. C & D (Pevidge-Cantwell-Gasconade soils). The watershed is 100% wooded.

   f. Average soil loss rates = 0.05 inch per hour approximately (For PMF storm, AMC III).

2. The combined discharge rating consisted of two components: the flow through the spillway and the flow going over the top of the dam.

   a. The spillway rating curve was developed using the Corps of Engineers, Water Surface Profile HEC-2 computer program. Critical depth was assumed at the downstream end of the concrete control.

   b. The flows over the dam were determined by using the dam overtopping analyses (irregular top of dam) within the HEC-1 (Dam Safety Version) program.

3. Floods were routed through the reservoir using the HEC-1 (Dam Safety Version) program to determine the capabilities of the spillway and dam embankment crest. The input, output and plotted hydrographs are attached in this Section.

GRAPH PAPER GRAPHIC CONTROLS CORPORATION Buffalo New York Printed in U.S.A. SQUARE 10 X 10 TO THE HALF INCH AS 6813 67

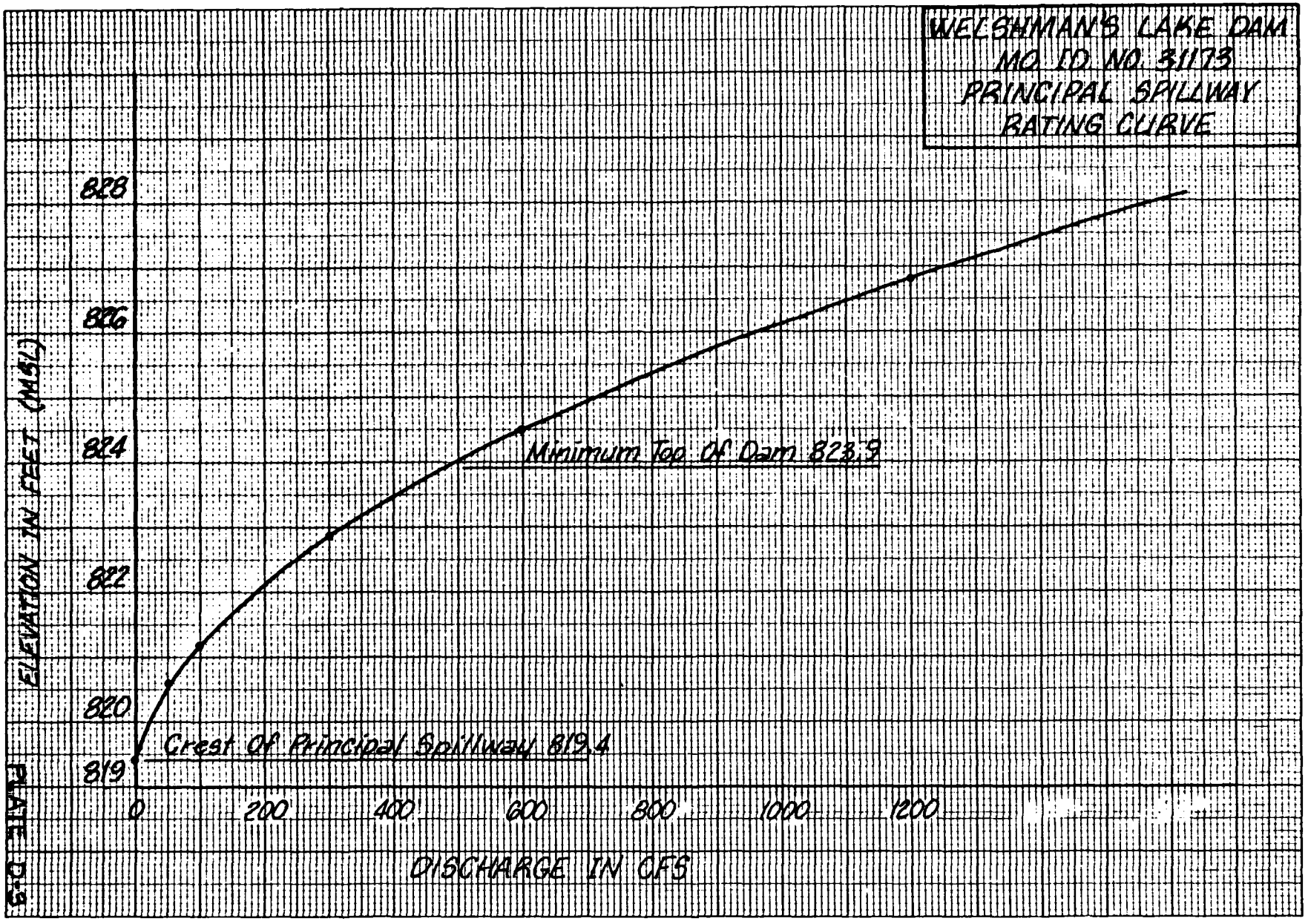


PLATE D-9

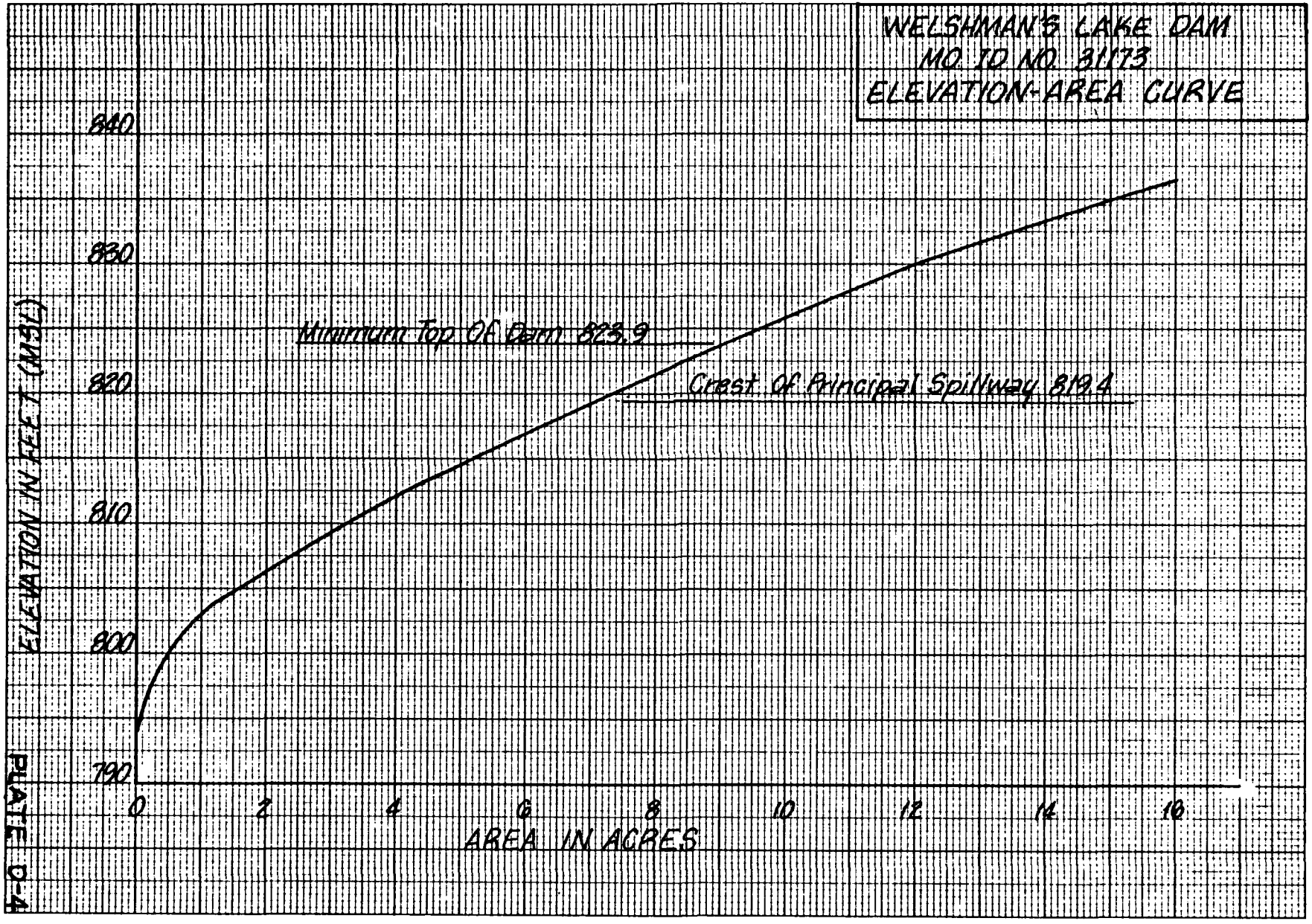


PLATE D-4

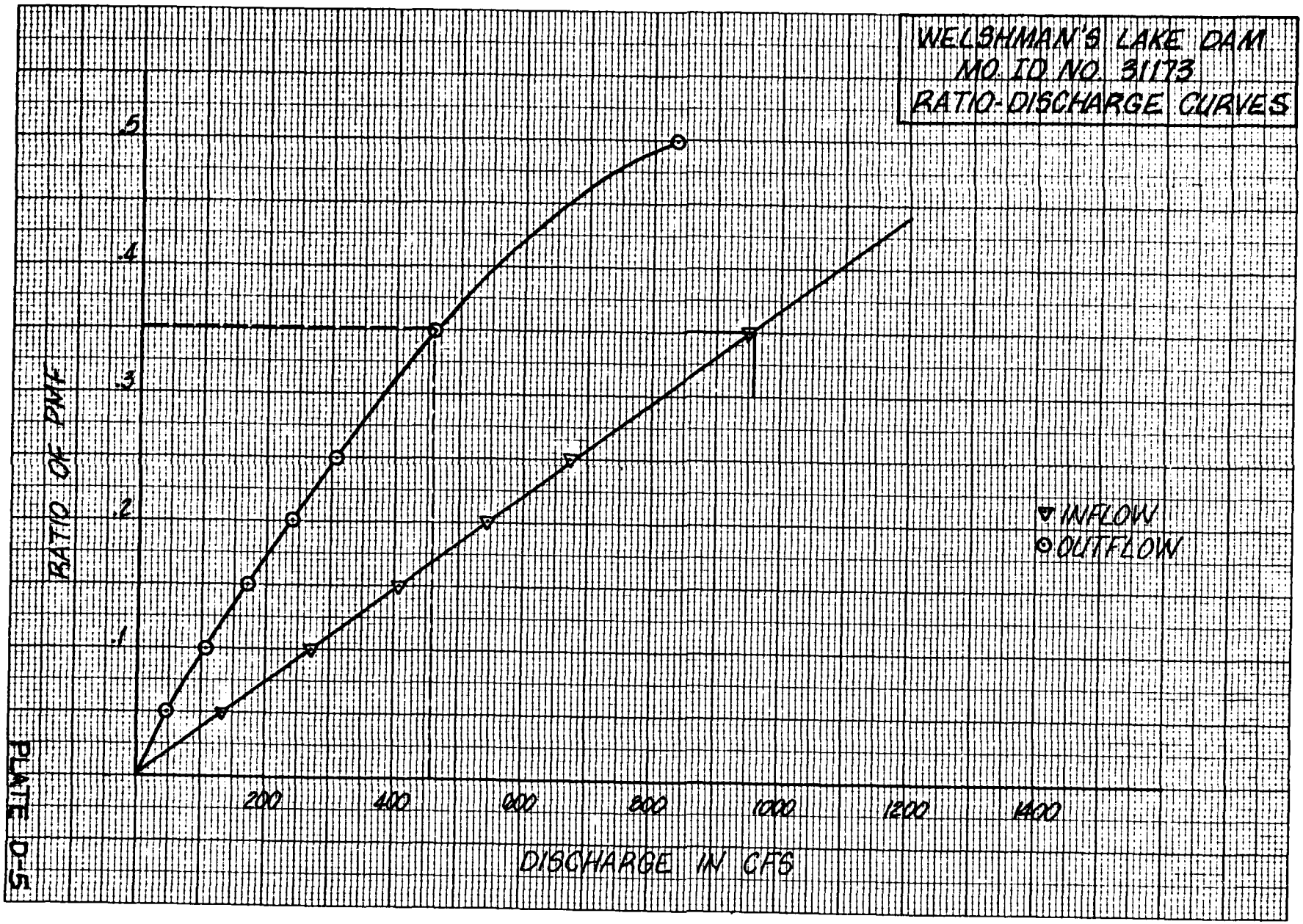


PLATE D-5

```
A1                        WELSHMANS LAKE DAM / MO. ID. NO 31173
A2       SAFETY ANALYSIS OF DAM OVERTOPPING USING ASSIGNED FLOOD FREQUENCIES
A3                 H & H ANALYSIS BY ROUTING PMF RATIOS THRU THE RESERVOIR
B    288000000000000005                                  000000000000000000000003
B1      5
J       10000000800000001
J1    .0500000,1000000,1500000,2000000,2500000,3500000,50000001,0
K       000000001                       000000000000000000000001
K1       CALCULATION OF INFLOW HYDRO TO WELSHMANS LAKE
M       1000000020000,2250000000000000,225000001,000000000000000000000001
P       0000026.10000010200000121000001 30
T                                                          -1.0    -89.0
W2      00000.17
X       0     -.0100000001
K       100000002                       000000020000000000000001
K1       ROUTED FLOWS THRU WELSHMANS LAKE DAM
Y                          0000000100000001
Y1      1                                                 -819.4       -1
Y4 819.4000820.0000820.6000821.2000822.1000822.9000823.5000824.1000824.5000825.3
Y4 826.1000826.8000827.1
Y5      000000020000000500000010000000200000003000000040000000500000006000000800
Y5  1000000012000000 1300
$A    0.0000000.5000001.6000003.2000005.3000007.4000009.6000012.0000015.1
$E 794.0000800.0000805.0000810.0000815.0000820.0000825.0000830.0000835.0
$$ 819.4
$D 823.9000002.8000001.500000420
$L      000000027000000700000012000000170000002000000025000000405000004200000044 5
$V 823.9000824.0000824.7000824.9000824.9000825.3000825.3000825.6000825.7000827.0
K      99
A
A
A
A
A
```

```
**********************************
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
 LAST MODIFICATION  26 FEB 79
**********************************

 RUN  DATE= 80/11/07.
      TIME= 10.40.06.
```

WELSHMANS LAKE DAM / MO. ID. NO 31173
SAFETY ANALYSIS OF DAM OVERTOPPING USING ASSIGNED FLOOD FREQUENCIES
H & H ANALYSIS BY ROUTING PMF RATIOS THRU THE RESERVOIR

JOB SPECIFICATION

NQ	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
288	0	5	0	0	0	0	0	3	0

JOPER	NWT	LROPT	TRACE
5	0	0	0

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 1 NRTIO= 8 LRTIO= 1

RTIOS=	.05	.10	.15	.20	.25	.35	.50	1.00

********** ********** ********** ********** **********

SUB-AREA RUNOFF COMPUTATION

CALCULATION OF INFLOW HYDRO TO WELSHMANS LAKE

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
000001	0	0	0	0	0	1	0	0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	2	.23	0.00	.23	1.00	0.000	0	1	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	26.10	102.00	121.00	130.00	0.00	0.00	0.00

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	-1.00	-89.00	0.00	0.00

CURVE NO = -89.00 WETNESS = -1.00 EFFECT CN = 89.00

UNIT HYDROGRAPH DATA
TC= 0.00 LAG= .17

RECESSION DATA
STRTQ= 0.00 QRCSN= -.01 RTIOR= 1.00

UNIT HYDROGRAPH 12 END OF PERIOD ORDINATES, TC= 0.00 HOURS, LAG= .17 VOL= 1.00

156.	472.	485.	304.	153.	82.	43.	23.	12.	6.
4.	1.								

0 END-OF-PERIOD FLOW

PLATE D-7

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	.05	1	.01	0.00	.01	0.	1.01	12.05	145	.22	.21	.01	139.
1.01	.10	2	.01	0.00	.01	0.	1.01	12.10	146	.22	.22	.01	209.
1.01	.15	3	.01	0.00	.01	0.	1.01	12.15	147	.22	.22	.01	282.
1.01	.20	4	.01	0.00	.01	0.	1.01	12.20	148	.22	.22	.01	327.
1.01	.25	5	.01	0.00	.01	0.	1.01	12.25	149	.22	.22	.01	350.
1.01	.30	6	.01	0.00	.01	0.	1.01	12.30	150	.22	.22	.01	363.
1.01	.35	7	.01	0.00	.01	0.	1.01	12.35	151	.22	.22	.00	370.
1.01	.40	8	.01	0.00	.01	0.	1.01	12.40	152	.22	.22	.00	374.
1.01	.45	9	.01	0.00	.01	0.	1.01	12.45	153	.22	.22	.00	376.
1.01	.50	10	.01	0.00	.01	0.	1.01	12.50	154	.22	.22	.00	377.
1.01	.55	11	.01	0.00	.01	0.	1.01	12.55	155	.22	.22	.00	378.
1.01	1.00	12	.01	0.00	.01	0.	1.01	13.00	156	.22	.22	.00	379.
1.01	1.05	13	.01	0.00	.01	0.	1.01	13.05	157	.27	.26	.00	386.
1.01	1.10	14	.01	0.00	.01	0.	1.01	13.10	158	.27	.26	.00	407.
1.01	1.15	15	.01	0.00	.01	0.	1.01	13.15	159	.27	.26	.00	429.
1.01	1.20	16	.01	0.00	.01	0.	1.01	13.20	160	.27	.26	.00	442.
1.01	1.25	17	.01	0.00	.01	0.	1.01	13.25	161	.27	.26	.00	449.
1.01	1.30	18	.01	0.00	.01	0.	1.01	13.30	162	.27	.26	.00	453.
1.01	1.35	19	.01	.00	.01	0.	1.01	13.35	163	.27	.26	.00	455.
1.01	1.40	20	.01	.00	.01	0.	1.01	13.40	164	.27	.26	.00	457.
1.01	1.45	21	.01	.00	.01	0.	1.01	13.45	165	.27	.26	.00	457.
1.01	1.50	22	.01	.00	.01	0.	1.01	13.50	166	.27	.26	.00	458.
1.01	1.55	23	.01	.00	.01	1.	1.01	13.55	167	.27	.26	.00	458.
1.01	2.00	24	.01	.00	.01	1.	1.01	14.00	168	.27	.26	.00	459.
1.01	2.05	25	.01	.00	.01	2.	1.01	14.05	169	.33	.33	.00	469.
1.01	2.10	26	.01	.00	.01	2.	1.01	14.10	170	.33	.33	.00	501.
1.01	2.15	27	.01	.00	.01	2.	1.01	14.15	171	.33	.33	.00	533.
1.01	2.20	28	.01	.00	.01	3.	1.01	14.20	172	.33	.33	.00	553.
1.01	2.25	29	.01	.00	.01	3.	1.01	14.25	173	.33	.33	.00	563.
1.01	2.30	30	.01	.00	.01	3.	1.01	14.30	174	.33	.33	.00	569.
1.01	2.35	31	.01	.00	.01	4.	1.01	14.35	175	.33	.33	.00	572.
1.01	2.40	32	.01	.00	.01	4.	1.01	14.40	176	.33	.33	.00	574.
1.01	2.45	33	.01	.00	.01	5.	1.01	14.45	177	.33	.33	.00	575.
1.01	2.50	34	.01	.00	.01	5.	1.01	14.50	178	.33	.33	.00	575.
1.01	2.55	35	.01	.00	.01	5.	1.01	14.55	179	.33	.33	.00	576.
1.01	3.00	36	.01	.00	.01	6.	1.01	15.00	180	.33	.33	.00	576.
1.01	3.05	37	.01	.00	.01	6.	1.01	15.05	181	.20	.20	.00	556.
1.01	3.10	38	.01	.00	.01	6.	1.01	15.10	182	.40	.40	.00	526.
1.01	3.15	39	.01	.00	.01	6.	1.01	15.15	183	.40	.40	.00	558.
1.01	3.20	40	.01	.00	.01	7.	1.01	15.20	184	.61	.60	.00	648.
1.01	3.25	41	.01	.00	.01	7.	1.01	15.25	185	.71	.71	.00	801.
1.01	3.30	42	.01	.00	.01	7.	1.01	15.30	186	1.72	1.71	.01	1123.
1.01	3.35	43	.01	.00	.01	8.	1.01	15.35	187	2.83	2.82	.01	1894.
1.01	3.40	44	.01	.00	.01	8.	1.01	15.40	188	1.11	1.11	.00	2708.
1.01	3.45	45	.01	.00	.01	8.	1.01	15.45	189	.71	.71	.00	2716.
1.01	3.50	46	.01	.01	.01	8.	1.01	15.50	190	.61	.61	.00	2188.
1.01	3.55	47	.01	.01	.01	9.	1.01	15.55	191	.40	.40	.00	1653.
1.01	4.00	48	.01	.01	.01	9.	1.01	16.00	192	.40	.40	.00	1264.
1.01	4.05	49	.01	.01	.01	9.	1.01	16.05	193	.31	.31	.00	993.
1.01	4.10	50	.01	.01	.01	9.	1.01	16.10	194	.31	.31	.00	803.
1.01	4.15	51	.01	.01	.01	9.	1.01	16.15	195	.31	.31	.00	683.
1.01	4.20	52	.01	.01	.01	10.	1.01	16.20	196	.31	.31	.00	615.
1.01	4.25	53	.01	.01	.01	10.	1.01	16.25	197	.31	.31	.00	579.
1.01	4.30	54	.01	.01	.01	10.	1.01	16.30	198	.31	.31	.00	559.
1.01	4.35	55	.01	.01	.01	10.	1.01	16.35	199	.31	.31	.00	548.
1.01	4.40	56	.01	.01	.01	10.	1.01	16.40	200	.31	.31	.00	543.
1.01	4.45	57	.01	.01	.01	11.	1.01	16.45	201	.31	.31	.00	541.
1.01	4.50	58	.01	.01	.01	11.	1.01	16.50	202	.31	.31	.00	540.
1.01	4.55	59	.01	.01	.01	11.	1.01	16.55	203	.31	.31	.00	540.
1.01	5.00	60	.01	.01	.01	11.	1.01	17.00	204	.31	.31	.00	540.

PLATE D-8

1.01	5.05	61	.01	.01	.01	11.	1.01	17.05	205	.24	.24	.00	530.
1.01	5.10	62	.01	.01	.01	12.	1.01	17.10	206	.24	.24	.00	498.
1.01	5.15	63	.01	.01	.01	12.	1.01	17.15	207	.24	.24	.00	466.
1.01	5.20	64	.01	.01	.01	12.	1.01	17.20	208	.24	.24	.00	446.
1.01	5.25	65	.01	.01	.01	12.	1.01	17.25	209	.24	.24	.00	436.
1.01	5.30	66	.01	.01	.01	12.	1.01	17.30	210	.24	.24	.00	430.
1.01	5.35	67	.01	.01	.01	12.	1.01	17.35	211	.24	.24	.00	427.
1.01	5.40	68	.01	.01	.01	12.	1.01	17.40	212	.24	.24	.00	426.
1.01	5.45	69	.01	.01	.01	13.	1.01	17.45	213	.24	.24	.00	425.
1.01	5.50	70	.01	.01	.01	13.	1.01	17.50	214	.24	.24	.00	425.
1.01	5.55	71	.01	.01	.01	13.	1.01	17.55	215	.24	.24	.00	424.
1.01	6.00	72	.01	.01	.01	13.	1.01	18.00	216	.24	.24	.00	424.
1.01	6.05	73	.07	.04	.03	18.	1.01	18.05	217	.02	.02	.00	389.
1.01	6.10	74	.07	.04	.03	35.	1.01	18.10	218	.02	.02	.00	284.
1.01	6.15	75	.07	.05	.02	52.	1.01	18.15	219	.02	.02	.00	175.
1.01	6.20	76	.07	.05	.02	65.	1.01	18.20	220	.02	.02	.00	106.
1.01	6.25	77	.07	.05	.02	72.	1.01	18.25	221	.02	.02	.00	72.
1.01	6.30	78	.07	.05	.02	77.	1.01	18.30	222	.02	.02	.00	54.
1.01	6.35	79	.07	.05	.02	81.	1.01	18.35	223	.02	.02	.00	44.
1.01	6.40	80	.07	.05	.02	84.	1.01	18.40	224	.02	.02	.00	39.
1.01	6.45	81	.07	.05	.02	86.	1.01	18.45	225	.02	.02	.00	37.
1.01	6.50	82	.07	.05	.02	88.	1.01	18.50	226	.02	.02	.00	35.
1.01	6.55	83	.07	.05	.01	90.	1.01	18.55	227	.02	.02	.00	34.
1.01	7.00	84	.07	.05	.01	92.	1.01	19.00	228	.02	.02	.00	34.
1.01	7.05	85	.07	.06	.01	93.	1.01	19.05	229	.02	.02	.00	34.
1.01	7.10	86	.07	.06	.01	95.	1.01	19.10	230	.02	.02	.00	34.
1.01	7.15	87	.07	.06	.01	96.	1.01	19.15	231	.02	.02	.00	34.
1.01	7.20	88	.07	.06	.01	97.	1.01	19.20	232	.02	.02	.00	34.
1.01	7.25	89	.07	.06	.01	98.	1.01	19.25	233	.02	.02	.00	34.
1.01	7.30	90	.07	.06	.01	99.	1.01	19.30	234	.02	.02	.00	34.
1.01	7.35	91	.07	.06	.01	100.	1.01	19.35	235	.02	.02	.00	34.
1.01	7.40	92	.07	.06	.01	101.	1.01	19.40	236	.02	.02	.00	34.
1.01	7.45	93	.07	.06	.01	102.	1.01	19.45	237	.02	.02	.00	34.
1.01	7.50	94	.07	.06	.01	103.	1.01	19.50	238	.02	.02	.00	34.
1.01	7.55	95	.07	.06	.01	103.	1.01	19.55	239	.02	.02	.00	34.
1.01	8.00	96	.07	.06	.01	104.	1.01	20.00	240	.02	.02	.00	34.
1.01	8.05	97	.07	.06	.01	105.	1.01	20.05	241	.02	.02	.00	34.
1.01	8.10	98	.07	.06	.01	105.	1.01	20.10	242	.02	.02	.00	34.
1.01	8.15	99	.07	.06	.01	106.	1.01	20.15	243	.02	.02	.00	34.
1.01	8.20	100	.07	.06	.01	106.	1.01	20.20	244	.02	.02	.00	34.
1.01	8.25	101	.07	.06	.01	107.	1.01	20.25	245	.02	.02	.00	34.
1.01	8.30	102	.07	.06	.01	107.	1.01	20.30	246	.02	.02	.00	34.
1.01	8.35	103	.07	.06	.01	108.	1.01	20.35	247	.02	.02	.00	34.
1.01	8.40	104	.07	.06	.01	108.	1.01	20.40	248	.02	.02	.00	34.
1.01	8.45	105	.07	.06	.01	109.	1.01	20.45	249	.02	.02	.00	34.
1.01	8.50	106	.07	.06	.01	109.	1.01	20.50	250	.02	.02	.00	34.
1.01	8.55	107	.07	.06	.01	109.	1.01	20.55	251	.02	.02	.00	34.
1.01	9.00	108	.07	.06	.01	110.	1.01	21.00	252	.02	.02	.00	34.
1.01	9.05	109	.07	.06	.01	110.	1.01	21.05	253	.02	.02	.00	34.
1.01	9.10	110	.07	.06	.01	110.	1.01	21.10	254	.02	.02	.00	34.
1.01	9.15	111	.07	.06	.01	111.	1.01	21.15	255	.02	.02	.00	34.
1.01	9.20	112	.07	.06	.00	111.	1.01	21.20	256	.02	.02	.00	34.
1.01	9.25	113	.07	.06	.00	111.	1.01	21.25	257	.02	.02	.00	34.
1.01	9.30	114	.07	.06	.00	111.	1.01	21.30	258	.02	.02	.00	34.
1.01	9.35	115	.07	.06	.00	112.	1.01	21.35	259	.02	.02	.00	34.
1.01	9.40	116	.07	.06	.00	112.	1.01	21.40	260	.02	.02	.00	34.
1.01	9.45	117	.07	.06	.00	112.	1.01	21.45	261	.02	.02	.00	34.
1.01	9.50	118	.07	.06	.00	112.	1.01	21.50	262	.02	.02	.00	34.
1.01	9.55	119	.07	.06	.00	113.	1.01	21.55	263	.02	.02	.00	34.
1.01	10.00	120	.07	.06	.00	113.	1.01	22.00	264	.02	.02	.00	34.
1.01	10.05	121	.07	.07	.00	113.	1.01	22.05	265	.02	.02	.00	34.
1.01	10.10	122	.07	.07	.00	113.	1.01	22.10	266	.02	.02	.00	34.

PLATE D-9

1.01	10.15	123	.07	.07	.00	113.	1.01	22.15	267	.02	.02	.00	34.
1.01	10.20	124	.07	.07	.00	113.	1.01	22.20	268	.02	.02	.00	34.
1.01	10.25	125	.07	.07	.00	114.	1.01	22.25	269	.02	.02	.00	34.
1.01	10.30	126	.07	.07	.00	114.	1.01	22.30	270	.02	.02	.00	34.
1.01	10.35	127	.07	.07	.00	114.	1.01	22.35	271	.02	.02	.00	34.
1.01	10.40	128	.07	.07	.00	114.	1.01	22.40	272	.02	.02	.00	34.
1.01	10.45	129	.07	.07	.00	114.	1.01	22.45	273	.02	.02	.00	34.
1.01	10.50	130	.07	.07	.00	114.	1.01	22.50	274	.02	.02	.00	34.
1.01	10.55	131	.07	.07	.00	114.	1.01	22.55	275	.02	.02	.00	34.
1.01	11.00	132	.07	.07	.00	115.	1.01	23.00	276	.02	.02	.00	34.
1.01	11.05	133	.07	.07	.00	115.	1.01	23.05	277	.02	.02	.00	34.
1.01	11.10	134	.07	.07	.00	115.	1.01	23.10	278	.02	.02	.00	34.
1.01	11.15	135	.07	.07	.00	115.	1.01	23.15	279	.02	.02	.00	34.
1.01	11.20	136	.07	.07	.00	115.	1.01	23.20	280	.02	.02	.00	34.
1.01	11.25	137	.07	.07	.00	115.	1.01	23.25	281	.02	.02	.00	34.
1.01	11.30	138	.07	.07	.00	115.	1.01	23.30	282	.02	.02	.00	34.
1.01	11.35	139	.07	.07	.00	115.	1.01	23.35	283	.02	.02	.00	34.
1.01	11.40	140	.07	.07	.00	115.	1.01	23.40	284	.02	.02	.00	34.
1.01	11.45	141	.07	.07	.00	116.	1.01	23.45	285	.02	.02	.00	34.
1.01	11.50	142	.07	.07	.00	116.	1.01	23.50	286	.02	.02	.00	34.
1.01	11.55	143	.07	.07	.00	116.	1.01	23.55	287	.02	.02	.00	34.
1.01	12.00	144	.07	.07	.00	116.	1.02	0.00	288	.02	.02	.00	34.
									SUM	33.93	32.49	1.44	56499.
										(862.)	(825.)	(37.)	(1599.87)

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	2716.	634.	196.	196.	56487.
CMS	77.	18.	6.	6.	1600.
INCHES		26.20	32.44	32.44	32.44
MM		665.59	823.87	823.87	823.87
AC-FT		314.	389.	389.	389.
THOUS CU M		388.	480.	480.	480.

HYDROGRAPH AT STA000001 FOR PLAN 1, RTIO 1

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	136.	32.	10.	10.	2824.
CMS	4.	1.	0.	0.	80.
INCHES		1.31	1.62	1.62	1.62
MM		33.28	41.19	41.19	41.19
AC-FT		16.	19.	19.	19.
THOUS CU M		19.	24.	24.	24.

HYDROGRAPH AT STA000001 FOR PLAN 1, RTIO 2

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	272.	63.	20.	20.	5649.
CMS	8.	2.	1.	1.	160.
INCHES		2.62	3.24	3.24	3.24
MM		66.56	82.39	82.39	82.39
AC-FT		31.	39.	39.	39.
THOUS CU M		39.	48.	48.	48.

HYDROGRAPH AT STA000001 FOR PLAN 1, RTIO 3

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	407.	95.	29.	29.	8473.
CMS	12.	3.	1.	1.	240.
INCHES		3.93	4.87	4.87	4.87
MM		99.84	123.58	123.58	123.58
AC-FT		47.	58.	58.	58.
THOUS CU M		58.	72.	72.	72.

HYDROGRAPH AT STA000001 FOR PLAN 1, RTIO 4

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	543.	127.	39.	39.	11297.
CMS	15.	4.	1.	1.	320.
INCHES		5.24	6.49	6.49	6.49
MM		133.12	164.77	164.77	164.77
AC-FT		63.	78.	78.	78.
THOUS CU M		78.	96.	96.	96.

HYDROGRAPH AT STA000001 FOR PLAN 1, RTIO 5

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	679.	158.	49.	49.	14122.
CMS	19.	4.	1.	1.	400.
INCHES		6.55	8.11	8.11	8.11
MM		166.40	205.97	205.97	205.97
AC-FT		79.	97.	97.	97.
THOUS CU M		97.	120.	120.	120.

HYDROGRAPH AT STA000001 FOR PLAN 1, RTIO 6

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	951.	222.	69.	69.	19771.
CMS	27.	6.	2.	2.	560.
INCHES		9.17	11.35	11.35	11.35
MM		232.96	288.36	288.36	288.36
AC-FT		110.	136.	136.	136.
THOUS CU M		136.	168.	168.	168.

HYDROGRAPH AT STA000001 FOR PLAN 1, RTIO 7 1/2 PMF

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	1358.	317.	98.	98.	28244.
CMS	38.	9.	3.	3.	800.
INCHES		13.10	16.22	16.22	16.22
MM		332.80	411.94	411.94	411.94
AC-FT		157.	195.	195.	195.
THOUS CU M		194.	240.	240.	240.

HYDROGRAPH AT STA000001 FOR PLAN 1, RTIO 8 PMF

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	2716.	634.	196.	196.	56487.

CMS	77.	18.	6.	6.	1600.
INCHES		26.20	32.44	32.44	32.44
MM		665.59	823.87	823.87	823.87
AC-FT		314.	389.	389.	389.
THOUS CU M		388.	480.	480.	480.

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HYDROGRAPH ROUTING

ROUTED FLOWS THRU WELSHMANS LAKE DAM

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
000002	1	0	0	2	0	1	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	-819.	-1

STAGE	819.40	820.00	820.60	821.20	822.10	822.90	823.50	824.10	824.50	825.30
	826.10	826.80	827.10							
FLOW	0.00	20.00	50.00	100.00	200.00	300.00	400.00	500.00	600.00	800.00
	1000.00	1200.00	1300.00							
SURFACE AREA=	0.	1.	2.	3.	5.	7.	10.	12.	15.	
CAPACITY=	0.	1.	6.	18.	39.	70.	113.	167.	234.	
ELEVATION=	794.	800.	805.	810.	815.	820.	825.	830.	835.	

CREL	SPWID	COQW	EXPW	ELEVL	COQL	CAREA	EXPL
819.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0

DAM DATA

TOPEL	COQD	EXPD	DAMWID
823.9	2.8	1.5	420.

CREST LENGTH	0.	27.	70.	120.	170.	200.	250.	405.	420.	445.
AT OR BELOW ELEVATION	823.9	824.0	824.7	824.9	824.9	825.3	825.3	825.6	825.7	827.0

~~STATION 000002, PLAN 1, RATIO 1~~

~~END-OF-PERIOD HYDROGRAPH ORDINATES~~

OUTFLOW

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	1.	1.	1.	1.	1.
1.	1.	1.	1.	1.	2.	2.	2.	2.	2.

PLATE D-12

OVN

STATION 000002, PLAN 1, RATIO 7 1/2 PMF

END-OF-PERIOD HYDROGRAPH ORDINATES

OUTFLOW

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	1.	1.	1.	2.	2.	2.
2.	2.	2.	2.	2.	2.	2.	3.	3.	3.
3.	3.	3.	3.	3.	3.	3.	3.	4.	4.
4.	4.	4.	4.	5.	6.	6.	7.	8.	9.
10.	11.	13.	14.	15.	16.	17.	17.	18.	19.
20.	22.	23.	24.	26.	27.	28.	29.	30.	31.
32.	33.	34.	35.	36.	37.	37.	38.	39.	40.
40.	41.	42.	42.	43.	43.	44.	45.	45.	46.
46.	46.	47.	47.	48.	48.	49.	49.	49.	50.
50.	50.	51.	51.	52.	52.	53.	53.	53.	54.
54.	54.	54.	55.	55.	58.	62.	69.	76.	83.
90.	97.	104.	112.	119.	126.	132.	138.	144.	151.
157.	163.	169.	174.	179.	184.	188.	191.	195.	199.
205.	211.	218.	224.	230.	236.	241.	245.	249.	253.
256.	257.	259.	263.	272.	292.	347.	445.	604.	774.
835.	799.	728.	652.	582.	524.	486.	461.	439.	419.
401.	385.	371.	359.	348.	336.	325.	313.	301.	293.
285.	279.	272.	267.	261.	257.	251.	243.	231.	215.
199.	184.	170.	156.	144.	132.	122.	112.	104.	97.
91.	86.	81.	76.	72.	68.	65.	61.	58.	55.
52.	50.	48.	47.	46.	44.	43.	42.	41.	40.
39.	38.	37.	36.	35.	34.	34.	33.	32.	32.
31.	30.	30.	29.	29.	28.	28.	27.	27.	26.
26.	25.	25.	25.	24.	24.	24.	23.	23.	23.
23.	22.	22.	22.	22.	21.	21.	21.		

STORAGE

66.	66.	66.	66.	66.	66.	66.	66.	66.	66.
66.	66.	66.	66.	66.	66.	66.	66.	66.	66.
66.	66.	66.	66.	66.	66.	66.	66.	66.	66.
66.	66.	66.	66.	66.	66.	66.	66.	66.	66.
66.	66.	66.	66.	66.	66.	66.	66.	66.	66.
66.	66.	66.	66.	67.	67.	67.	67.	67.	67.
67.	67.	67.	67.	67.	67.	67.	67.	67.	67.
67.	67.	67.	67.	67.	67.	67.	68.	68.	68.
68.	69.	69.	69.	69.	69.	70.	70.	70.	70.
70.	71.	71.	71.	71.	71.	72.	72.	72.	72.
72.	72.	72.	73.	73.	73.	73.	73.	73.	73.
73.	74.	74.	74.	74.	74.	74.	74.	74.	74.
74.	74.	74.	75.	75.	75.	75.	75.	75.	75.
75.	75.	75.	75.	75.	75.	75.	75.	75.	75.
75.	75.	75.	75.	75.	76.	76.	77.	77.	78.
79.	79.	80.	80.	81.	81.	82.	82.	83.	83.
84.	84.	85.	85.	85.	86.	86.	86.	86.	87.
87.	88.	88.	88.	89.	89.	90.	90.	90.	90.
91.	91.	91.	91.	92.	93.	96.	101.	107.	111.
112.	111.	110.	108.	106.	105.	103.	102.	101.	100.
99.	98.	97.	97.	96.	96.	95.	94.	94.	93.
93.	92.	92.	91.	91.	91.	90.	90.	89.	88.
87.	86.	85.	84.	83.	82.	81.	80.	80.	79.
79.	78.	78.	77.	77.	77.	76.	76.	76.	75.

PLATE D-13

75.	75.	75.	74.	74.	74.	74.	74.	74.	73.
73.	73.	73.	73.	73.	73.	72.	72.	72.	72.
72.	72.	72.	72.	72.	72.	72.	71.	71.	71.
71.	71.	71.	71.	71.	71.	71.	71.	71.	71.
71.	71.	71.	71.	71.	71.	71.	71.		

STAGE

819.4	819.4	819.4	819.4	819.4	819.4	819.4	819.4	819.4	819.4
819.4	819.4	819.4	819.4	819.4	819.4	819.4	819.4	819.4	819.4
819.4	819.4	819.4	819.4	819.4	819.4	819.4	819.4	819.4	819.4
819.4	819.4	819.4	819.4	819.4	819.4	819.4	819.4	819.4	819.4
819.4	819.4	819.4	819.4	819.4	819.4	819.4	819.4	819.5	819.5
819.5	819.5	819.5	819.5	819.5	819.5	819.5	819.5	819.5	819.5
819.5	819.5	819.5	819.5	819.5	819.5	819.5	819.5	819.5	819.5
819.5	819.5	819.5	819.5	819.5	819.6	819.6	819.6	819.7	819.7
819.7	819.7	819.8	819.8	819.8	819.9	819.9	819.9	820.0	820.0
820.0	820.0	820.1	820.1	820.1	820.1	820.2	820.2	820.2	820.2
820.2	820.3	820.3	820.3	820.3	820.3	820.3	820.4	820.4	820.4
820.4	820.4	820.4	820.4	820.5	820.5	820.5	820.5	820.5	820.5
820.5	820.5	820.5	820.5	820.6	820.6	820.6	820.6	820.6	820.6
820.6	820.6	820.6	820.6	820.6	820.6	820.6	820.6	820.6	820.6
820.6	820.7	820.7	820.7	820.7	820.7	820.7	820.8	820.9	821.0
821.1	821.2	821.2	821.3	821.4	821.4	821.5	821.5	821.6	821.7
821.7	821.8	821.8	821.9	821.9	822.0	822.0	822.0	822.1	822.1
822.1	822.2	822.2	822.3	822.3	822.4	822.4	822.5	822.5	822.5
822.5	822.6	822.6	822.6	822.7	822.8	823.2	823.8	824.4	824.8
824.9	824.8	824.7	824.5	824.3	824.2	824.0	823.9	823.7	823.6
823.5	823.4	823.3	823.3	823.2	823.1	823.0	823.0	822.9	822.8
822.8	822.7	822.7	822.6	822.6	822.6	822.5	822.4	822.3	822.2
822.1	822.0	821.8	821.7	821.6	821.5	821.4	821.3	821.2	821.2
821.1	821.0	821.0	820.9	820.9	820.8	820.8	820.7	820.7	820.7
820.6	820.6	820.6	820.5	820.5	820.5	820.5	820.4	820.4	820.4
820.4	820.4	820.3	820.3	820.3	820.3	820.3	820.3	820.2	820.2
820.2	820.2	820.2	820.2	820.2	820.2	820.2	820.1	820.1	820.1
820.1	820.1	820.1	820.1	820.1	820.1	820.1	820.1	820.1	820.1
820.1	820.0	820.0	820.0	820.0	820.0	820.0	820.0		

PEAK OUTFLOW IS 835. AT TIME 15.92 HOURS

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	835.	300.	96.	96.	27591.
CMS	24.	8.	3.	3.	781.
INCHES		12.40	15.84	15.84	15.84
MM		314.95	402.41	402.41	402.41
AC-FT		149.	190.	190.	190.
THOUS CU M		183.	234.	234.	234.

PLATE D-14

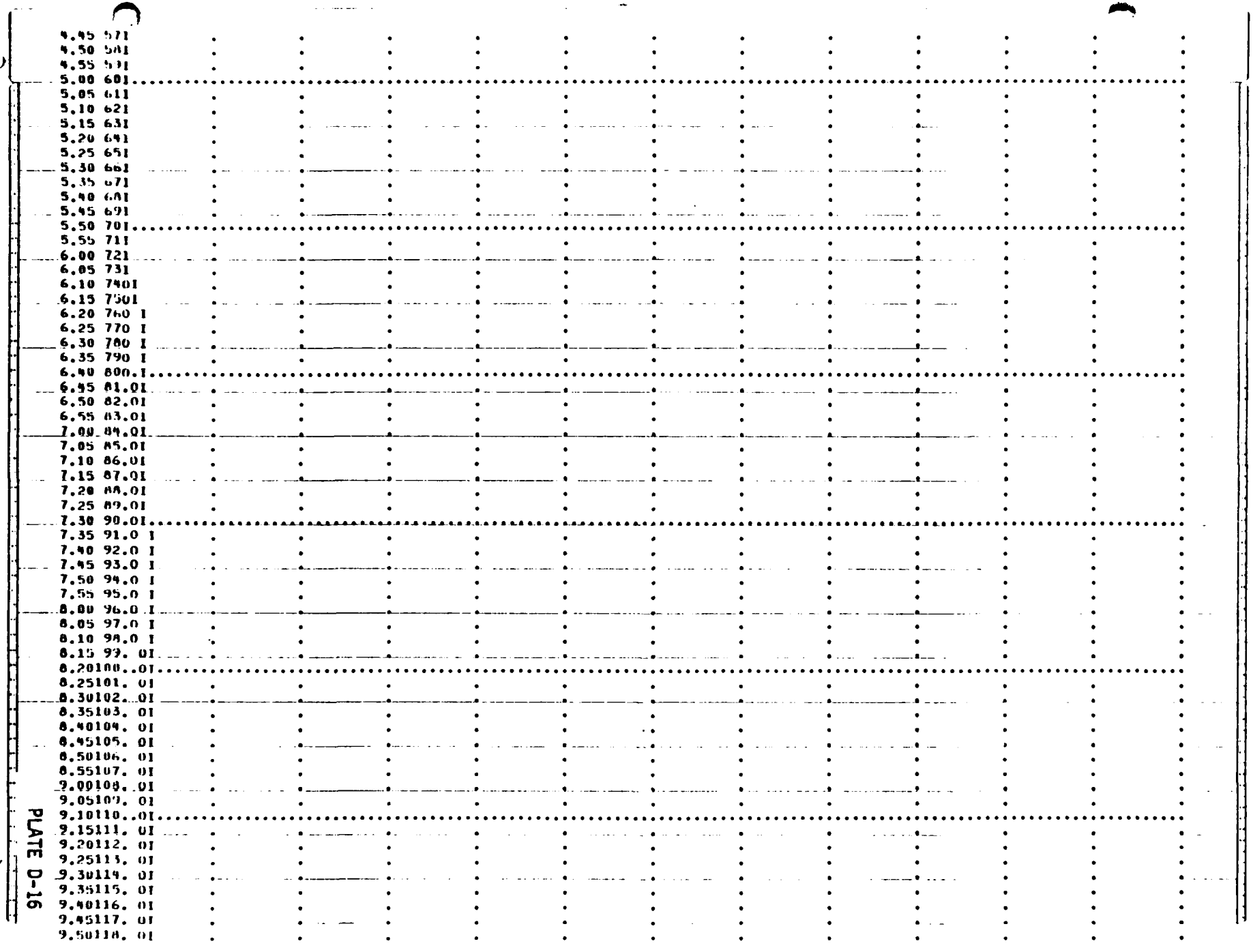
OVF

STATION000002

INFLOW(I), OUTFLOW(O) AND OBSERVED FLOW(*)

	0.	200.	400.	600.	800.	1000.	1200.	1400.	0.	0.	0.	0.	0.
.05	1I												
.10	2I												
.15	3I												
.20	4I												
.25	5I												
.30	6I												
.35	7I												
.40	8I												
.45	9I												
.50	10I												
.55	11I												
1.00	12I												
1.05	13I												
1.10	14I												
1.15	15I												
1.20	16I												
1.25	17I												
1.30	18I												
1.35	19I												
1.40	20I												
1.45	21I												
1.50	22I												
1.55	23I												
2.00	24I												
2.05	25I												
2.10	26I												
2.15	27I												
2.20	28I												
2.25	29I												
2.30	30I												
2.35	31I												
2.40	32I												
2.45	33I												
2.50	34I												
2.55	35I												
3.00	36I												
3.05	37I												
3.10	38I												
3.15	39I												
3.20	40I												
3.25	41I												
3.30	42I												
3.35	43I												
3.40	44I												
3.45	45I												
3.50	46I												
3.55	47I												
4.00	48I												
4.05	49I												
4.10	50I												
4.15	51I												
4.20	52I												
4.25	53I												
4.30	54I												
4.35	55I												
4.40	56I												

PLATE D-15


4.45 571
4.50 581
4.55 591
5.00 601
5.05 611
5.10 621
5.15 631
5.20 641
5.25 651
5.30 661
5.35 671
5.40 681
5.45 691
5.50 701
5.55 711
6.00 721
6.05 731
6.10 740I
6.15 750I
6.20 760 I
6.25 770 I
6.30 780 I
6.35 790 I
6.40 800.I
6.45 81.0I
6.50 82.0I
6.55 83.0I
7.00 84.0I
7.05 85.0I
7.10 86.0I
7.15 87.0I
7.20 88.0I
7.25 89.0I
7.30 90.0I
7.35 91.0 I
7.40 92.0 I
7.45 93.0 I
7.50 94.0 I
7.55 95.0 I
8.00 96.0 I
8.05 97.0 I
8.10 98.0 I
8.15 99. 0I
8.20100..0I
8.25101. 0I
8.30102..0I
8.35103. 0I
8.40104. 0I
8.45105. 0I
8.50106. 0I
8.55107. 0I
9.00108..0I
9.05109. 0I
9.10110..0I
9.15111. 0I
9.20112. 0I
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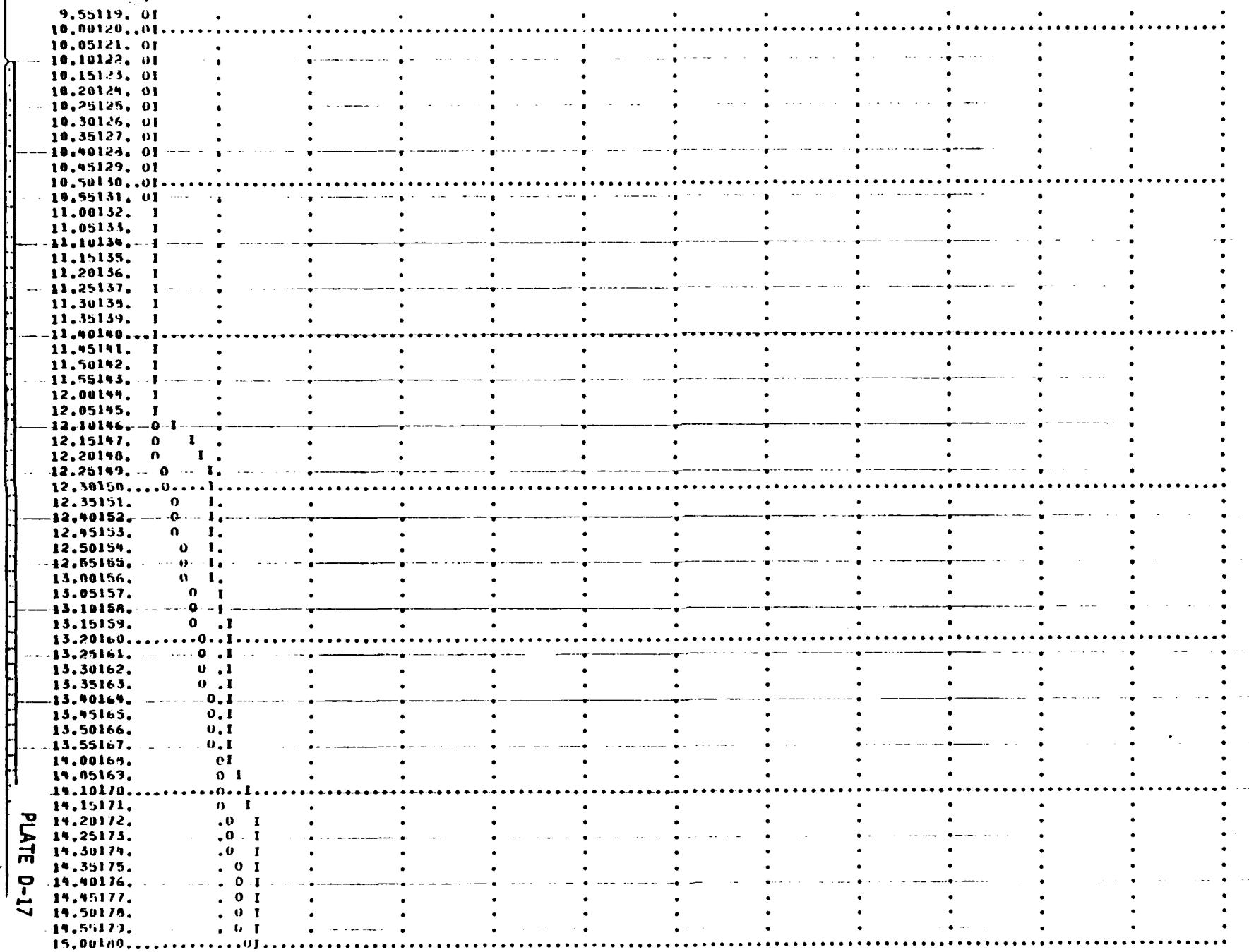
9.35115. 0I
9.40116. 0I
9.45117. 0I
9.50118. 0I

PLATE D-16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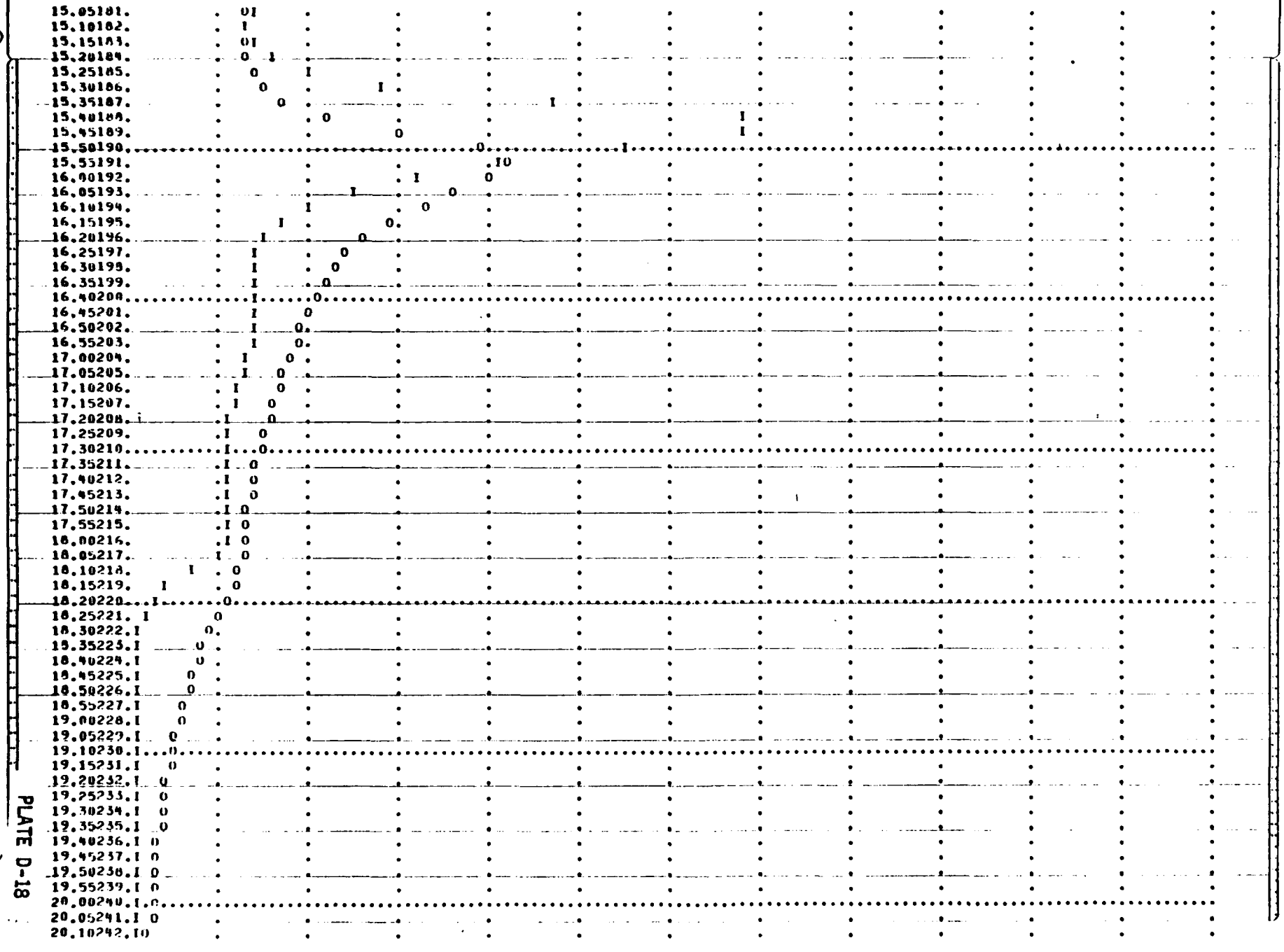
10.25125. 0I
10.30126. 0I
10.35127. 0I
10.40128. 0I
10.45129. 0I
10.50130. 0I
10.55131. 0I
11.00132. I
11.05133. I
11.10134. I
11.15135. I
11.20136. I
11.25137. I
11.30138. I
11.35139. I
11.40140. I
11.45141. I
11.50142. I
11.55143. I
12.00144. I
12.05145. I
12.10146. 0 I
12.15147. 0 I
12.20148. 0 I
12.25149. 0 I
12.30150. 0 I
12.35151. 0 I.
12.40152. 0 I.
12.45153. 0 I.
12.50154. 0 I.
12.55155. 0 I.
13.00156. 0 I.
13.05157. 0 I
13.10158. 0 I
13.15159. 0 .I
13.20160. 0 .I
13.25161. 0 .I
13.30162. 0 .I
13.35163. 0 .I
13.40164. 0.I
13.45165. 0.I
13.50166. 0.I
13.55167. 0.I
14.00168. 0I
14.05169. 0 I
14.10170. 0 I
14.15171. 0 I
14.20172. .0 I
14.25173. .0 I
14.30174. .0 I
14.35175. . 0 I
14.40176. . 0 I
14.45177. . 0 I
14.50178. . 0 I
14.55179. . 0 I
15.00180. 0I

PLATE D-17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15.10182.
15.15183.
15.20184.
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15.30186.
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15.40188.
15.45189.
15.50190.
15.55191.
16.00192.
16.05193.
16.10194.
16.15195.
16.20196.
16.25197.
16.30198.
16.35199.
16.40200.
16.45201.
16.50202.
16.55203.
17.00204.
17.05205.
17.10206.
17.15207.
17.20208.
17.25209.
17.30210.
17.35211.
17.40212.
17.45213.
17.50214.
17.55215.
18.00216.
18.05217.
18.10218.
18.15219.
18.20220.
18.25221.
18.30222.
18.35223.
18.40224.
18.45225.
18.50226.
18.55227.
19.00228.
19.05229.
19.10230.
19.15231.
19.20232.
19.25233.
19.30234.
19.35235.
19.40236.
19.45237.
19.50238.
19.55239.
20.00240.
20.05241.
20.10242.

PLATE D-18

20.15243.10
20.20244.10
20.25245.10
20.30246.10
20.35247.10
20.40248.10
20.45249.10
20.50250.10
20.55251.10
21.00252.10
21.05253.10
21.10254.10
21.15255.10
21.20256.10
21.25257.10
21.30258.10
21.35259.10
21.40260.10
21.45261.10
21.50262.10
21.55263.1
22.00264.1
22.05265.1
22.10266.1
22.15267.1
22.20268.1
22.25269.1
22.30270.1
22.35271.1
22.40272.1
22.45273.1
22.50274.1
22.55275.1
23.00276.1
23.05277.1
23.10278.1
23.15279.1
23.20280.1
23.25281.1
23.30282.1
23.35283.1
23.40284.1
23.45285.1
23.50286.1
23.55287.1
0.00288.1

PLATE D-19

•OVN•

STATION 000002, PLAN 1, RATIO 8 PMF

END-OF-PERIOD HYDROGRAPH ORDINATES

OUTFLOW

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1.	1.	1.	1.	1.	1.	1.	1.	2.	2.
2.	2.	2.	2.	3.	3.	3.	3.	3.	4.
4.	4.	4.	4.	4.	5.	5.	5.	5.	5.
6.	6.	6.	6.	6.	6.	7.	7.	7.	7.
7.	8.	8.	8.	9.	11.	13.	15.	17.	19.
21.	24.	27.	30.	33.	35.	38.	41.	43.	46.
48.	51.	54.	58.	61.	64.	67.	70.	72.	75.
77.	79.	81.	83.	85.	86.	88.	90.	91.	92.
94.	95.	96.	97.	98.	99.	100.	101.	102.	103.
104.	105.	106.	106.	107.	108.	108.	109.	109.	110.
110.	110.	111.	111.	112.	112.	112.	112.	113.	113.
113.	113.	114.	114.	115.	121.	132.	148.	165.	182.
198.	215.	231.	245.	258.	269.	280.	291.	304.	321.
336.	350.	363.	374.	384.	393.	401.	408.	415.	423.
434.	447.	461.	473.	486.	498.	511.	524.	535.	548.
549.	547.	546.	559.	590.	692.	976.	1770.	2541.	2465.
2013.	1590.	1289.	1082.	928.	820.	750.	698.	659.	630.
608.	592.	580.	570.	562.	551.	536.	519.	504.	493.
484.	477.	471.	465.	460.	456.	450.	437.	412.	379.
343.	309.	282.	259.	238.	218.	200.	185.	172.	159.
148.	138.	128.	120.	112.	105.	99.	94.	90.	86.
82.	79.	76.	73.	70.	67.	65.	63.	61.	59.
57.	55.	54.	52.	51.	50.	49.	49.	48.	47.
47.	46.	46.	45.	45.	44.	44.	43.	43.	42.
42.	42.	41.	41.	41.	40.	40.	40.	40.	39.
39.	39.	39.	39.	38.	38.	38.	38.		

STORAGE

66.	66.	66.	66.	66.	66.	66.	66.	66.	66.
66.	66.	66.	66.	66.	66.	66.	66.	66.	66.
66.	66.	66.	66.	66.	66.	66.	66.	66.	66.
66.	66.	66.	66.	66.	66.	66.	66.	66.	66.
66.	66.	67.	67.	67.	67.	67.	67.	67.	67.
67.	67.	67.	67.	67.	67.	67.	67.	67.	67.
67.	67.	67.	67.	67.	67.	67.	68.	68.	68.
68.	68.	68.	68.	68.	68.	69.	69.	70.	70.
71.	71.	71.	72.	72.	73.	73.	73.	74.	74.
75.	75.	75.	76.	76.	76.	76.	77.	77.	77.
77.	78.	78.	78.	78.	78.	78.	79.	79.	79.
79.	79.	79.	79.	79.	79.	80.	80.	80.	80.
80.	80.	80.	80.	80.	80.	80.	80.	80.	80.
80.	80.	80.	80.	80.	80.	80.	80.	80.	81.
81.	81.	81.	81.	81.	81.	82.	83.	84.	86.
87.	88.	89.	90.	91.	92.	92.	93.	94.	95.
96.	96.	97.	98.	98.	99.	99.	99.	100.	100.
101.	101.	102.	103.	103.	104.	105.	105.	105.	105.
106.	106.	106.	106.	107.	109.	114.	120.	124.	124.
121.	119.	117.	115.	113.	112.	110.	109.	108.	108.
107.	107.	106.	106.	106.	106.	105.	105.	104.	104.
103.	103.	103.	102.	102.	102.	102.	101.	100.	98.
96.	94.	92.	91.	89.	88.	87.	86.	85.	84.
83.	82.	82.	81.	80.	80.	79.	79.	79.	78.

PLATE D-20

78.	78.	77.	77.	77.	77.	76.	76.	76.	76.
76.	75.	75.	75.	75.	75.	75.	75.	75.	74.
74.	74.	74.	74.	74.	74.	74.	74.	74.	74.
74.	74.	74.	74.	74.	73.	73.	73.	73.	73.
73.	73.	73.	73.	73.	73.	73.	73.		

STAGE

819.4	819.4	819.4	819.4	819.4	819.4	819.4	819.4	819.4	819.4
819.4	819.4	819.4	819.4	819.4	819.4	819.4	819.4	819.4	819.4
819.4	819.4	819.4	819.4	819.4	819.4	819.4	819.4	819.4	819.4
819.4	819.4	819.4	819.4	819.4	819.4	819.4	819.4	819.4	819.5
819.5	819.5	819.5	819.5	819.5	819.5	819.5	819.5	819.5	819.5
819.5	819.5	819.5	819.5	819.5	819.6	819.6	819.5	819.6	819.6
819.6	819.6	819.6	819.6	819.6	819.6	819.6	819.6	819.6	819.6
819.6	819.6	819.6	819.7	819.7	819.7	819.8	819.8	819.9	820.0
820.0	820.1	820.1	820.2	820.3	820.3	820.4	820.4	820.5	820.5
820.6	820.6	820.7	820.7	820.7	820.8	820.8	820.8	820.9	820.9
820.9	820.9	821.0	821.0	821.0	821.0	821.1	821.1	821.1	821.1
821.1	821.1	821.2	821.2	821.2	821.2	821.2	821.2	821.2	821.2
821.2	821.2	821.2	821.3	821.3	821.3	821.3	821.3	821.3	821.3
821.3	821.3	821.3	821.3	821.3	821.3	821.3	821.3	821.3	821.3
821.3	821.3	821.3	821.3	821.3	821.4	821.5	821.6	821.8	821.9
822.1	822.2	822.3	822.5	822.6	822.7	822.7	822.8	822.9	823.0
823.1	823.2	823.3	823.3	823.4	823.5	823.5	823.5	823.6	823.6
823.7	823.8	823.9	823.9	824.0	824.1	824.1	824.2	824.2	824.2
824.2	824.2	824.2	824.3	824.4	824.6	825.1	825.7	826.1	826.1
825.9	825.6	825.4	825.2	825.0	824.9	824.7	824.6	824.5	824.5
824.4	824.4	824.3	824.3	824.3	824.2	824.2	824.1	824.1	824.0
824.0	824.0	823.9	823.9	823.9	823.8	823.8	823.7	823.6	823.4
823.2	823.0	822.8	822.6	822.4	822.2	822.1	822.0	821.8	821.7
821.6	821.5	821.5	821.4	821.3	821.2	821.2	821.1	821.1	821.0
821.0	820.9	820.9	820.9	820.8	820.8	820.8	820.8	820.7	820.7
820.7	820.7	820.6	820.6	820.6	820.6	820.6	820.6	820.6	820.5
820.5	820.5	820.5	820.5	820.5	820.5	820.5	820.5	820.5	820.4
820.4	820.4	820.4	820.4	820.4	820.4	820.4	820.4	820.4	820.4
820.4	820.4	820.4	820.4	820.4	820.4	820.4	820.4		

PEAK OUTFLOW IS 2541. AT TIME 15.75 HOURS

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	2541.	609.	193.	193.	55471.
CMS	72.	17.	5.	5.	1571.
INCHES		25.19	31.85	31.85	31.85
MM		639.77	809.06	809.06	809.06
AC-FT		302.	382.	382.	382.
THOUS CU M		373.	471.	471.	471.

PLATE D-21

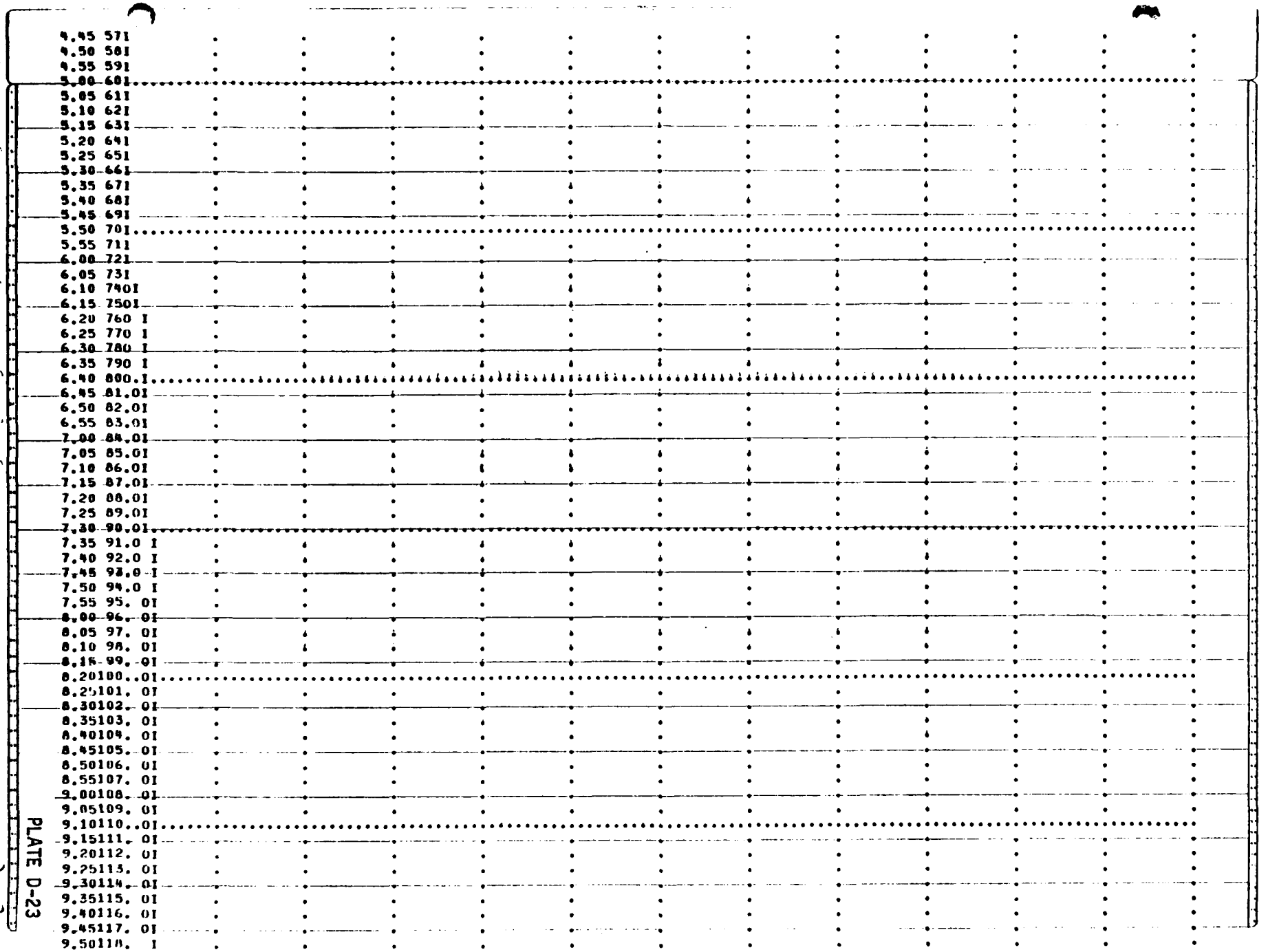
OVF

STATION000002

INFLOW(I), OUTFLOW(O) AND OBSERVED FLOW(*)

	0.	400.	800.	1200.	1600.	2000.	2400.	2800.	0.	0.	0.	0.	0.
.05	11												
.10	21												
.15	31												
.20	41												
.25	51												
.30	61												
.35	71												
.40	81												
.45	91												
.50	101												
.55	111												
1.00	121												
1.05	131												
1.10	141												
1.15	151												
1.20	161												
1.25	171												
1.30	181												
1.35	191												
1.40	201												
1.45	211												
1.50	221												
1.55	231												
2.00	241												
2.05	251												
2.10	261												
2.15	271												
2.20	281												
2.25	291												
2.30	301												
2.35	311												
2.40	321												
2.45	331												
2.50	341												
2.55	351												
3.00	361												
3.05	371												
3.10	381												
3.15	391												
3.20	401												
3.25	411												
3.30	421												
3.35	431												
3.40	441												
3.45	451												
3.50	461												
3.55	471												
4.00	481												
4.05	491												
4.10	501												
4.15	511												
4.20	521												
4.25	531												
4.30	541												
4.35	551												
4.40	561												

PLATE D-22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5.20 64I
5.25 65I
5.30 66I
5.35 67I
5.40 68I
5.45 69I
5.50 70I
5.55 71I
6.00 72I
6.05 73I
6.10 74OI
6.15 75OI
6.20 760 I
6.25 770 I
6.30 780 I
6.35 790 I
6.40 800.I
6.45 81.0I
6.50 82.0I
6.55 83.0I
7.00 84.0I
7.05 85.0I
7.10 86.0I
7.15 87.0I
7.20 88.0I
7.25 89.0I
7.30 90.0I
7.35 91.0 I
7.40 92.0 I
7.45 93.0 I
7.50 94.0 I
7.55 95. 0I
8.00 96. 0I
8.05 97. 0I
8.10 98. 0I
8.15 99. 0I
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PLATE D-23

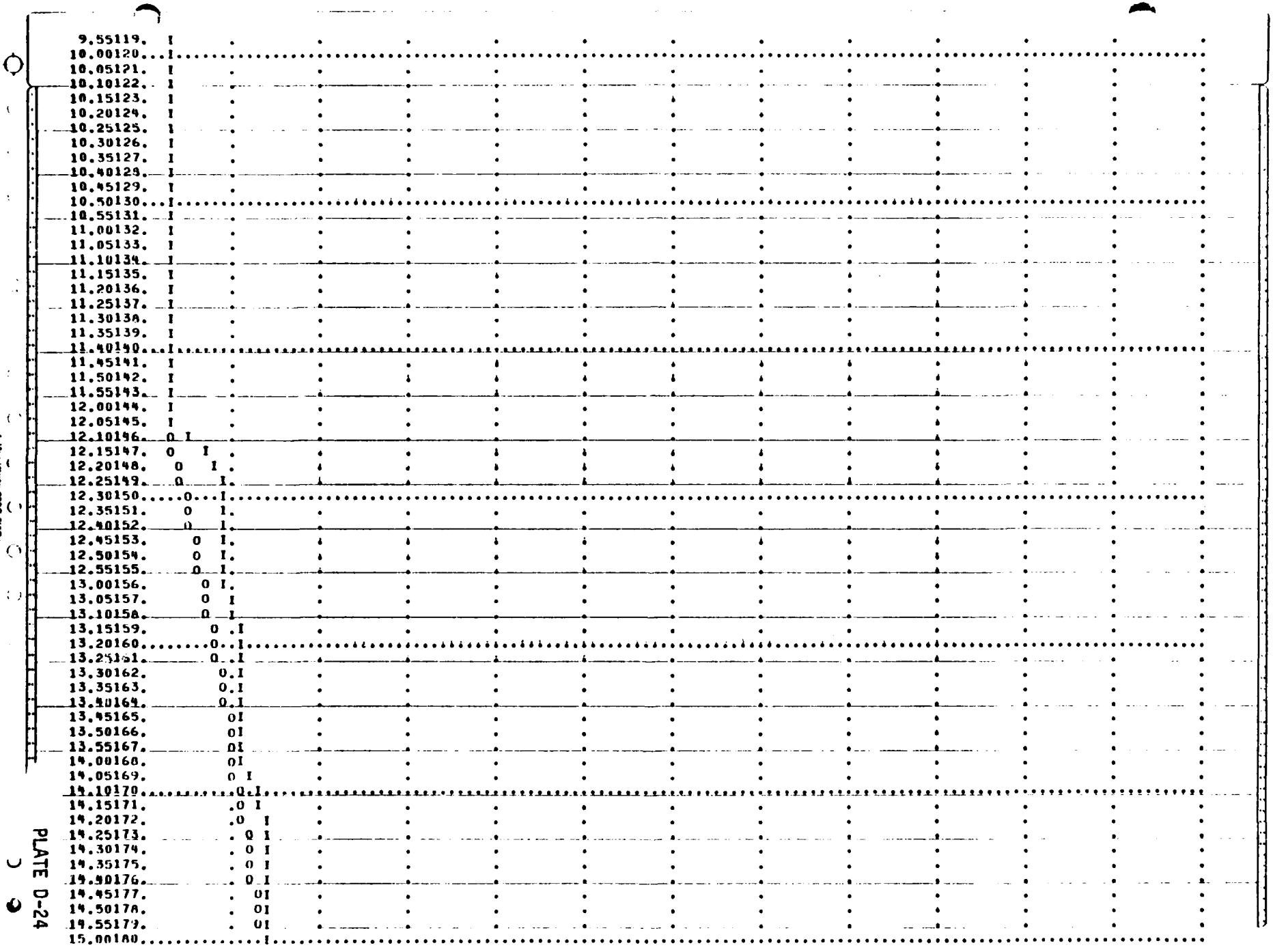
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PLATE D-24

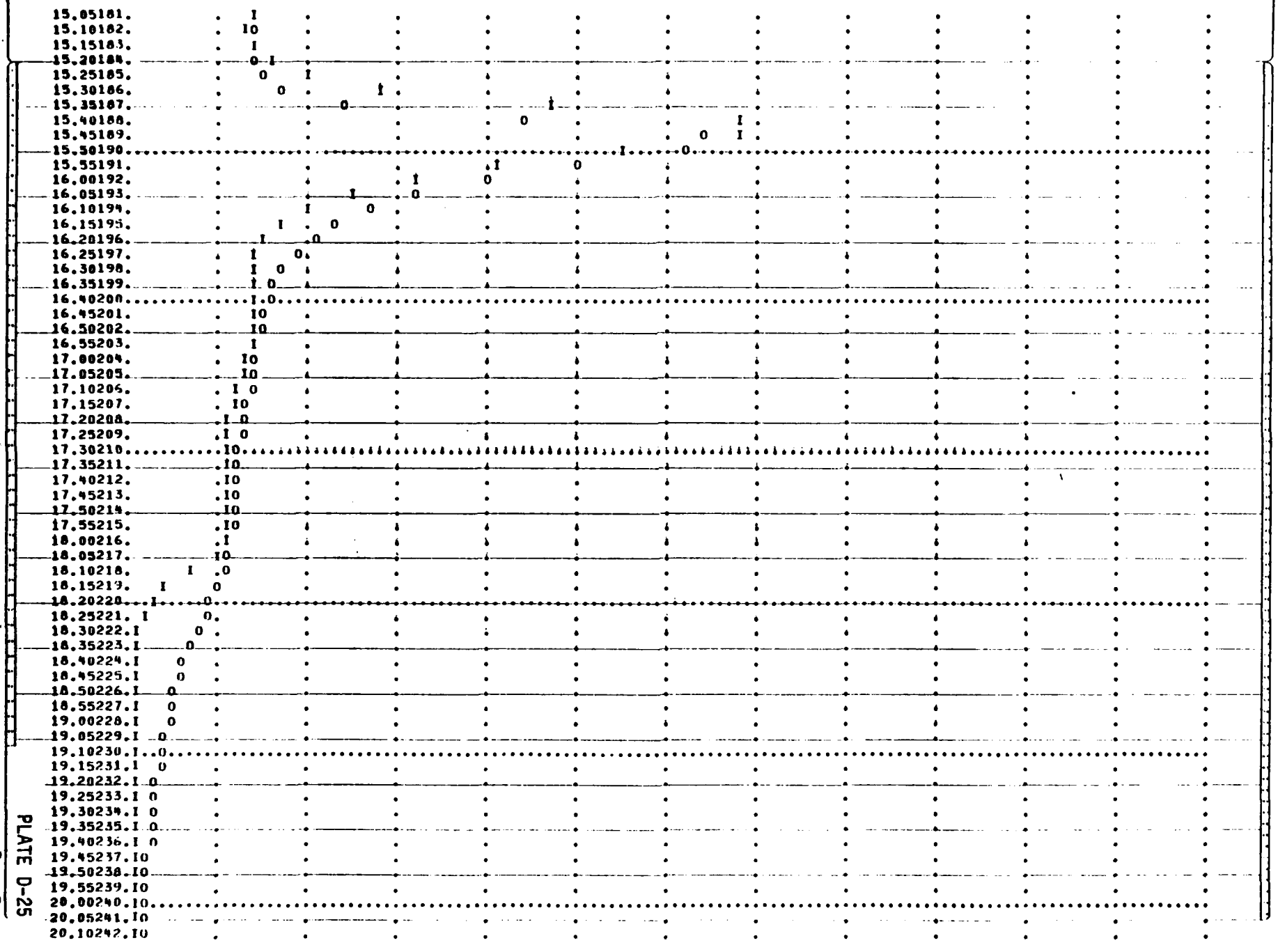
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PLATE D-25

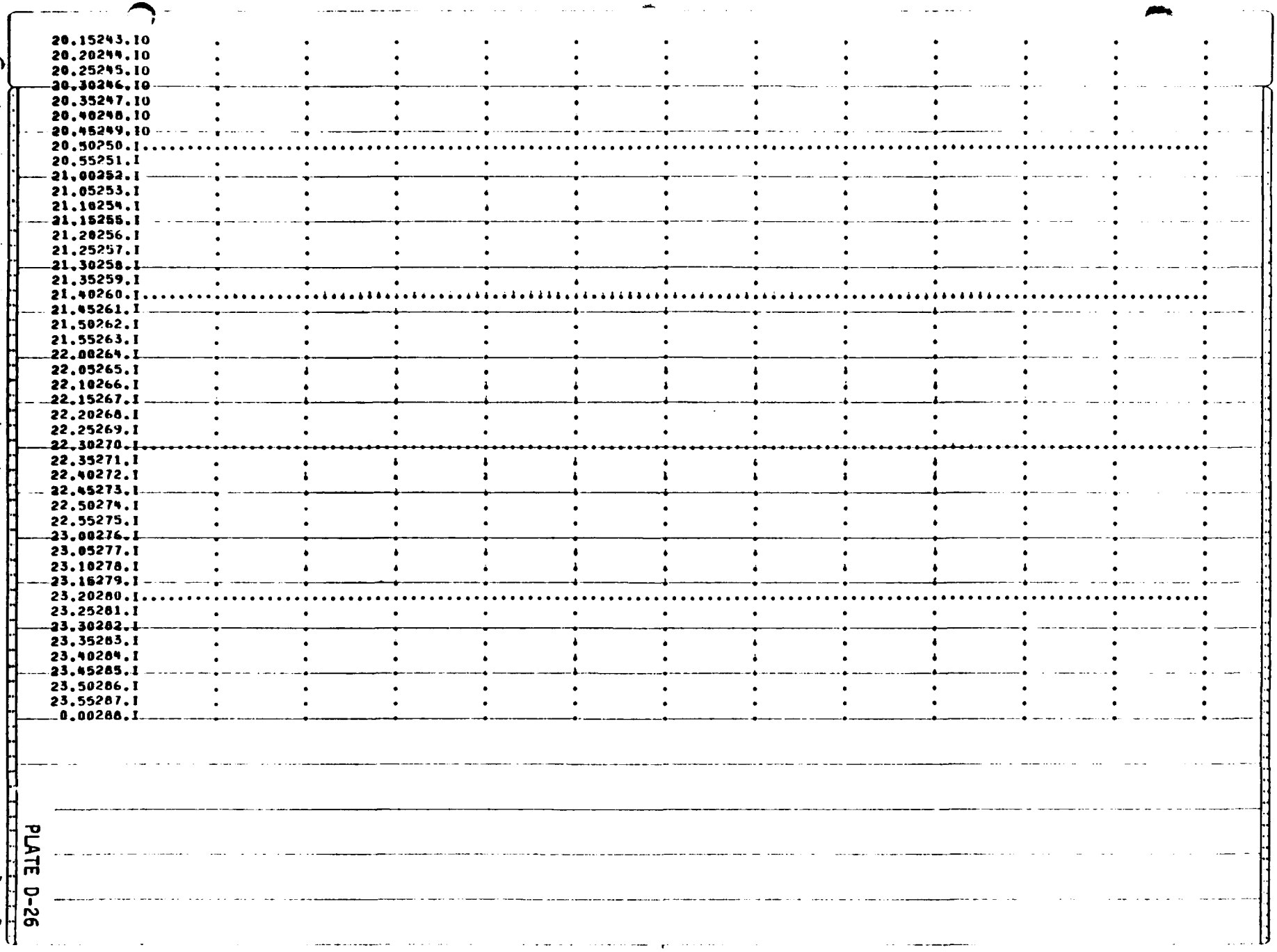
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PLATE D-26

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS							
				RATIO 1 .05	RATIO 2 .10	RATIO 3 .15	RATIO 4 .20	RATIO 5 .25	RATIO 6 .35	RATIO 7 .50	RATIO 8 1.00
HYDROGRAPH AT	000001	.23	1	136.	272.	407.	543.	679.	951.	1358.	2716.
		(.58)		(3.85)(	7.69)(	11.54)(	15.38)(	19.23)(	26.92)(	38.46)(	76.92)(
ROUTED TO	000002	.23	1	41.	102.	173.	241.	309.	462.	835.	2541.
		(.58)		(1.16)(	2.89)(	4.90)(	6.83)(	8.74)(	13.08)(	23.65)(	71.95)(

PLATE D-27

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	819.40	819.40	823.90
STORAGE	66.	66.	102.
OUTFLOW	0.	0.	467.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.05	820.42	0.00	74.	41.	0.00	16.17	0.00
.10	821.22	0.00	80.	102.	0.00	16.08	0.00
.15	821.86	0.00	85.	173.	0.00	16.00	0.00
.20	822.43	0.00	90.	241.	0.00	16.00	0.00
.25	822.95	0.00	94.	309.	0.00	16.00	0.00
.35	823.87	0.00	102.	462.	0.00	16.00	0.00
.50	824.90	1.00	112.	835.	.75	15.92	0.00
1.00	826.13	2.23	124.	2541.	3.33	15.75	0.00

PLATE D-28

APPENDIX E

GEOLOGY REPORT

ENGINEERING GEOLOGY OF THE PAUL J. WILLIAMS LAKE SITE, ST. FRANCOIS COUNTY

The proposed Paul Williams lake site located in the SE¼ SW¼ sec. 15, T.37 N., R.4 E. (Bonne Terre Quad.) is geologically feasible. If the following recommendations based on geological conditions are followed little or no trouble is anticipated.

Geologically this site is located in the Derby-Doerun Formation which consists of thin bedded limestone, silts, and shales. The soil cover varies in thickness but seldom will be found over 10 feet in thickness. This soil will be quite adequate for embankment material if the material is placed in lifts and compacted to its maximum density. Although most of the stone was covered at the dam site there are indications that alternating beds of thin limestones and shales will be encountered which will cause little difficulty in constructing an adequate core trench. However, it is very important that all loose limestone blocks be removed down to fresh solid rock. The loose material should be removed off the silt and shale horizons. If the core is not cut into fresh solid limestone rock especially on the abutments then there will be a possibility of leakage through bedding planes of the thin bedded limestone along the bedding planes. The use of powder should be kept at a minimum and could possibly be used to insure good trenches on the abutments but probably should not be used on the floor of the valley. The core trench in the flood of the valley should be cut to fresh rock and the limestone slabs that can be broken and pulled out with a back mounted ripper on the large cat should be sufficient.

The material from the core trench can be put off to one side and incorporated as part of the downstream portion of the embankment. Due to the alternating beds of limestone and shale it is recommended that a blanket of natural soil be left for approximately 50 to 75 feet upstream from the toe of the dam. This will aid in restricting the flow of water underneath the embankment material.

Edwin E. Lutzen

Edwin E. Lutzen
Engineering Geologist
Missouri Geological Survey
April 29, 1969

END

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